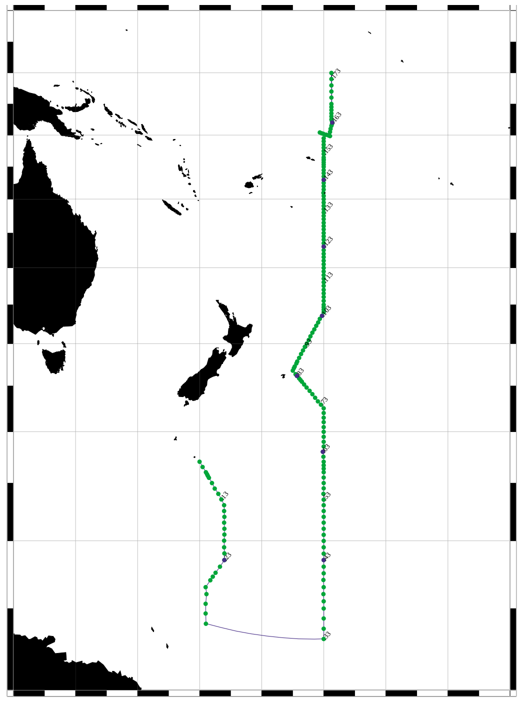
Cruise Narrative: P14S P15S

(Updated 8 DEC 2004)



A. Highlights

WHP Cruise Summary Information

	Leg 1	Leg 2
WOCE section designation	**P14S**	**P15S**
Expedition designation (EXPOCODE)	**31DSCG96_1,**	**31DSCG96_2**
Co-Chief Scientists / affiliation*	**J Bullister / G Johnson**	**R Feeley / M Roberts**
Dates	1996 JAN 05 – 1996 FEB 04 (Stns 1-93)	1996 FEB 12 – 1996 MAR 10 (Stns 94-182)
Ship	*R/V DISCOVERER*	
Ports of call	Hobart, Tasmania- Wellington, NZ	Wellington, NZ- Pago Pago, Samoa
Station geographic boundaries	40° 23.58 S 169° 59.27 E 169° 58.3 W 67° 0.03 S	0° 0.01 S 173° 2.13 W 168° 36.87 W 40° 23.66 S
Stations	29	144
Floats and drifters deployed	14 ALACE floats deployed	
Moorings deployed or recovered	0	
Contributing Authors	John Bullister, Calvin Mordy, Kristy McTaggart, Greg Johnson, Kirk Hargreaves, Arnold Mantyla, Mark Rosenberg, David Wisegarver	

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WHP Cruise and Data Information

Links to text locations. Shaded items are not relevant to this cruise or were not available when this report was compiled

Cruise Summary Information	**Hydrographic Measurements**		
Description of Scientific Program	**CTD Data: Introduction**		
Geographic Boundaries		**Calibration**	
Cruise Track (Figure)	Salinity	Pre-Cruise	Post-Cruise
Description of Stations	Temperature	Pre-Cruise	Post-Cruise
Description of Parameters Sampled	Pressure	Pre-Cruise	Post-Cruise
Bottle Depth Distributions (Figure)	Oxygen	Pre-Cruise	Post-Cruise
	Bottle Data		
Floats and Drifters Deployed	Salinity		
Moorings Deployed or Recovered	Oxygen		
	Nutrients		
Principal Investigators for All Measurements	CFCs		
Cruise Participants	CO_2 System Parameters		
	Helium Tritium		
Problems and Goals Not Achieved	Radiocarbon		
Other Incidents of Note	Other Parameters		

Underway Data Information	**DQE Reports**
Navigation Bathymetry	CTD
Acoustic Doppler Current Profiler (ADCP)	S/O_2/Nutrients
Thermosalinograph and Related Measurements	CFCs
XBT and/or XCTD	14C
Meteorological Observations	
Atmospheric Chemistry Data	

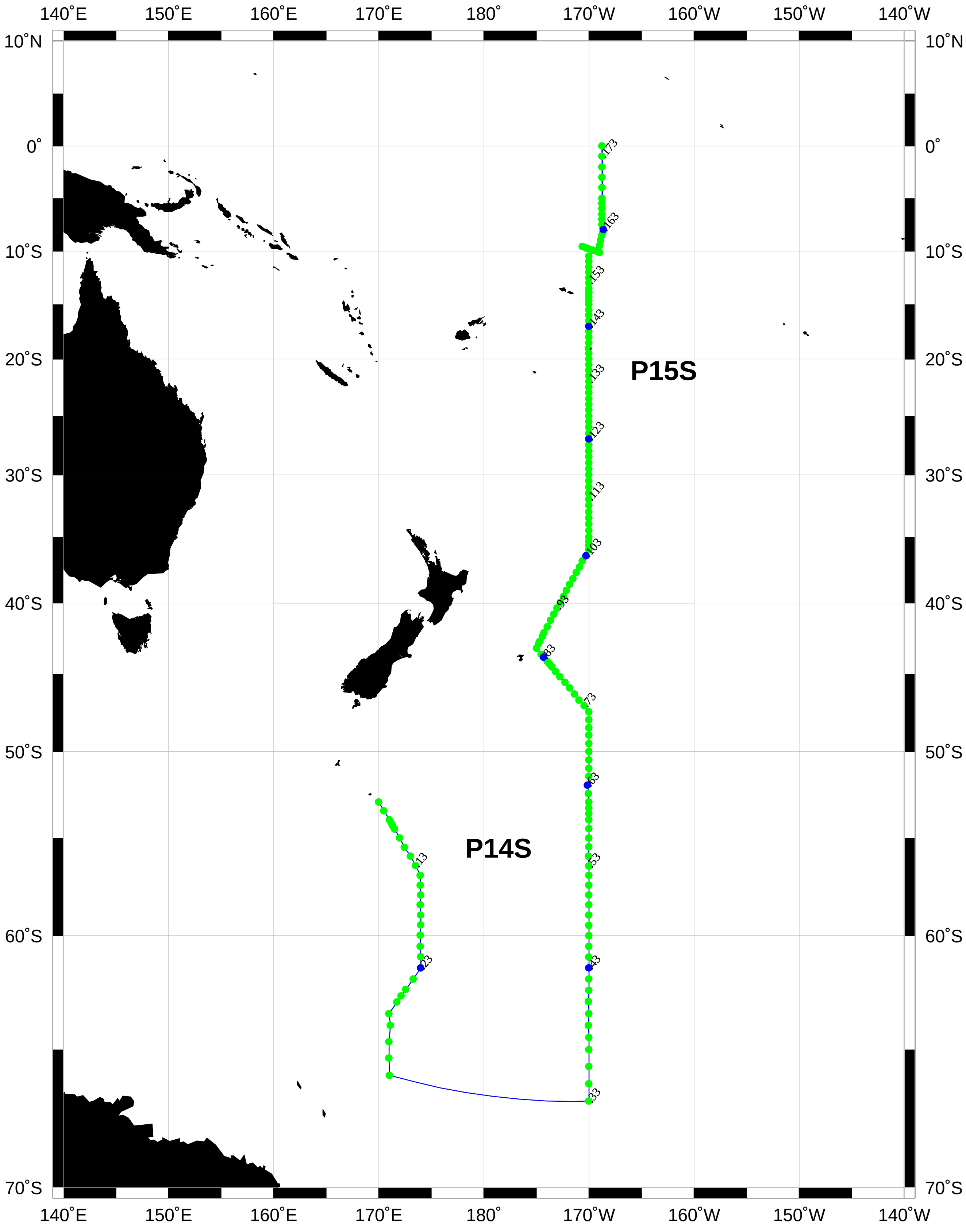
Acknowledgments | **Data Processing Notes**

References

Oxygen Nutrients CFCs CO_2 CTD CTD DQE CFC DQE

Cruise Report:	WHP Lines P14S and P15S (CGC96 cruise)
Prepared by:	John Bullister, NOAA-PMEL
Date of this (NOAA-PMEL) draft:	12 June 2000
Updated by WHPO:	12 July 2003

Station Locations for P14S and P15S • *R/V Discoverer* • 1996



Produced from .sum file by WHPO-SIO

Cruise Track

The station locations are shown in Fig. 1 and listed in the P14S P15S .sum file.
182 Stations were completed:

3	test stations on the transit leg from Hobart to the start of the P14S section (2 thirty-six position rosette stations; 1 twenty-four position rosette station)
29	stations on the P14S section (17 thirty-six position rosette stations; 12 twenty-four position rosette stations)
144	stations on the P15S section (132 thirty-six position rosette stations; 10 twenty-four position rosette stations)
6	thirty-six position rosette stations in a short section across Samoan Passage
1	shallow primary productivity cast (with light meter) was made each day.

Approximately Number of Water Samples Analysed

5700 Salinity
5700 Oxygen
5700 Nutrients
3300 CFC-11 and CFC-12
1000 CFC-113 and carbon tetrachloride
3100 Total CO_2
3000 pCO_2
5700 pH
3100 Alkalinity
1350 DOC

Approximate Number of Water Samples Collected for Shore-Based Analysis

- 975 AMS carbon isotope samples (C-13 and C-14)
- 1025 DON

Floats

14 ALACE floats were deployed (8 standard and 6 stretched profilers).

STNNBR	Latitude	Longitude	Date	Time
1	56 29.7 S	173 32.4 E	11 Jan 96	0323
2	59 27.5 S	173 57.9 E	12 Jan 96	0035
3	60 29.7 S	170 01.3 W	22 Jan 96	0606 Profiler
4	57 30.1 S	170 00.7 W	23 Jan 96	2120 Profiler
5	55 29.5 S	170 01.9 W	24 Jan 96	2321 Profiler
6	53 59.5 S	169 59.3 W	25 Jan 96	1545 Profiler
7	52 00.0 S	170 05.7 W	26 Jan 96	0155 Profiler
8	50 00.4 S	170 00.4 W	28 Jan 96	0502 Profiler
9	47 29.5 S	169 58.6 W	29 Jan 96	1505
10	45 10.6 S	172 43.8 W	31 Jan 96	0701
11	42 23.7 S	174 24.6 W	1 Feb 96	2143
12	39 04.4 S	172 06.8 W	14 Feb 96	1820
13	29 59.2 S	169 59.5 W	20 Feb 96	0125
14	24 29.9 S	170 00.1 W	22 Feb 96	0252

ADCP

Lowered ADCP profiles were obtained at about 70 stations on Leg 1 using a rosette mounted lowered ADCP instrument on 36 position rosette frame. Continuous underway ADCP measurements were made along the cruise track.

Atmospheric Chemistry Data:

Air samples were collected at approximately 3 degrees intervals for analyses of atmospheric CFCs.

Participating Institutions

NOAA Pacific Marine Environmental Laboratory	(PMEL)
NOAA Atlantic Oceanographic and Meteorological Laboratory	(AOML)
Bermuda Biological Station for Research	(BBSR)
Monterey Bay Aquarium Research Institute	(MBARI)
Scripps Institution of Oceanography	(SIO)
Oregon State University	(OSU)
Institute of Ocean Sciences	(IOS)
University of Tennessee	(UT)
University of Hawaii	(UH)
University of Miami	(UM)
University of South Florida	(USF)
University of Charleston, South Carolina	(UCSC)
University of Washington	(UW)

Principal Investigators

Measurements	Principal Investigators (PI)	Institution	Funding Agency
CTD/O_2 and bottle salinity	Greg Johnson	PMEL	(NOAA)
Chlorofluorocarbons (CFCs)	John Bullister	PMEL	(NOAA)
Total CO_2 (DIC), pCO_2	Dick Feely, Rik Wanninkhof	PMEL/AOML	(NOAA)
C-14 (AMS radiocarbon), C-13	Paul Quay	UW	(NOAA)
Nutrients	Calvin Mordy, Zia-Zhong Zhang	PMEL/AOML	(NOAA)
Dissolved Oxygen (discrete)	John Bullister	PMEL	(NOAA)
Total Alkalinity	Frank Millero	UM	(NOAA)
pH	Robert Byrne	USF	(NOAA)
UW pH/DIC	Andrew Dickson	SIO	(NOAA)
DOC/DON	Dennis Hansell	BBSR	(NOAA)
ADCP	Peter Hacker/Eric Firing	U Hawaii	
ALACE Float deployment	Russ Davis	SIO	
Primary Productivity	Jack DiTullio, Walker Smith	UCSC/UT	(NOAA)
UW Chlorophyll	F. Chavez	MBARI	(NOAA)
Bathymetry	Ship personnel		
Underway thermosalinograph	Ship personnel		

Narrative

WOCE Hydrographic Sections P14S and P15S were completed on the NOAA Ship Discoverer in early 1996, measuring a wide suite of physical, chemical, and biological processes. A total of 182 full-water column CTD/O_2 stations were made along the sections (Fig. 1). A 36 position rosette was used as the primary system. On Leg 1, a lowered ADCP system was mounted on the 36 position rosette, reducing the number of available 10-liter sample bottles to 34.

Of the 182 stations, 159 stations were made with the 36-position, 10-liter bottle frame. The other 23 stations were made using a 24-position, 4-liter bottle frame, which was deployed primarily during bad weather.

A Sea-Bird Electronics 911plus CTD was mounted in each frame. In addition to the set of temperature and conductivity sensors resident on each CTD, a mobile set of temperature and conductivity sensors with a dissolved oxygen sensor was always mounted on the CTD in use. This arrangement allowed redundant temperature and conductivity measurements for quality control and continuity of temperature and conductivity measurements while keeping each CTD mounted in its own frame.

Water samples were collected at every station for analyses of salt, dissolved oxygen, and dissolved nutrients (silicate, nitrate, nitrite, and phosphate). Fig. 2a and 2b show locations where water samples were collected. Samples were drawn at selected locations for analysis of CFC-11, CFC-12, CFC-113, carbon tetrachloride, dissolved inorganic carbon (DIC), total alkalinity, pH, pCO_2, dissolved organic carbon (DOC), carbon isotopes, oxygen isotopes, and other variables (see P14SP15s.sum file).

Daily shallow casts were made for assessment of various biological parameters, including productivity.

A total of 14 ALACE floats were deployed during the cruise, including 6 "Stretched T Profilers".

For both sections sampled on this cruise, stations were occupied at a nominal spacing of 30 nm, closer over steeply sloped bathymetry, and never more distant than 60 nm. Stations 1-3 were test stations occupied to evaluate the CTD/O_2 and rosette systems on the transit from Hobart, Australia to the start of P14S. Stations 177 to 182 were taken after the completion of P15S but prior to the final port stop in Pago-Pago, American Samoa. These profiles constitute a short, nearly zonal, section across the Samoan Passage, taken to investigate deep water-mass and transport variability there. These data are reported here. The cruise was broken up into two legs of roughly one month duration each by a port stop in Wellington, New Zealand after station 93. Station 94 was a reoccupation of station 93 to evaluate temporal variations that occurred during the port stop.

WOCE section P14S began with station 4 at 53°S, 170°E in 200 m of water on the south edge of the Campbell Plateau and ended with station 32 at 66°S, 171°E, intersecting the zonal WHP section S4 occupied nominally along 67°S in 1992. The section consisted of 29 stations. It sampled the entire Antarctic Circumpolar Current between the edge of the Campbell Plateau and the crest of the Pacific-Antarctic Ridge. At the ridge crest it explored a deep passage between the Ross Sea and the Southwest Pacific Basin. South of the ridge crest, it entered the north side of the Ross Sea Gyre.

WOCE section P15S began with station 33 at 67°S, 170°W, again intersecting the zonal WHP section S4 occupied nominally along 67°S in 1992. It proceeded north to station 72 at 47.5°S, 170°W, whereupon it followed a diagonal in towards the Chatham Rise until station 85 at 43.25°S, 175°E. From there it moved back away from the rise towards 170°W along a diagonal to station 104 at 36°S, 170°W. It then resumed north to station 154 at 10.5°S, 170°W, whereupon it shifted longitudes slightly to follow the axis of the Samoan Passage until station 164 at 7.5° S, 168.75°W.

From there it continued north to station 174 at the equator, 168.75°W. Station 175 and 176 were added to the section to improve meridional resolution in the vicinity of the Samoan Passage. From 15° S to the equator the section overlapped WHP section P15N, occupied in 1994. The P15S section consisted of 143 stations, discounting the duplication after the Wellington port stop. It sampled the north end of the Ross Sea Gyre, the Antarctic Circumpolar Current, the Deep Western Boundary Current system on both flanks of the Chatham Rise, the Subtropical Gyre, and the Tropical Regime up to the equator.

Problems

In general, the ship, winches and analytical systems performed well on this expedition. All of the major goals of the program were met. At the completion of the P14S and P15S sections, enough time remained to extend the P15S section from 5°S to the equator and to complete an additional 8 stations in Samoan Passage. Some time was lost at the beginning of Leg 1 due to problems with the level-wind mechanism on the primary winch. The wire was re-tensioned on the drum at sea by removing the CTD/rosette package, attaching a weight to the wire, and spooling the full length of the wire (except the last full wrap on the drum) behind the ship while underway. Level-wind problems were much reduced after this procedure.

Figs. 3-18 show preliminary sections of bottle salinity, dissolved oxygen, phosphate, silicate, nitrate, CFC-11, CFC-12. These preliminary sections only utilize values listed in the P14S and P15S.sea file which are flagged as "good" (flags 2 or 6) and where the BTLNBR flag is also 2. Bathymetry shown in these figures is from depth recorded at each station.

Participating Scientists

Program	Inst.	Leg 1		Leg 2		Nationality (if non-US)
Chief Sci.	**PMEL**	**John Bullister**	**M**	**Richard Feely**	**M**	
Co-Chief Sci.	PMEL	Greg Johnson	M	Marilyn Roberts	F	
CTD/O_2	PMEL	Kristy McTaggart	F	Kristy McTaggart	F	
	OSU			Jim Richman	M	
	IOS	John Love	M			(CANADA)
SeaBird		Norge Larson	M			
Nutrients	PMEL	Calvin Mordy	M	Calvin Mordy	M	
	AOML	Zia-Zhong Zhang	M	Zia-Zhong Zhang	M	(PRC)
Oxygen	PMEL	Kirk Hargreaves	M	Kirk Hargreaves	M	
Salinity	AOML	Gregg Thomas	M	Gregg Thomas	M	
CFC	PMEL	Dave Wisegarver	M	Dave Wisegarver	M	
	PMEL	Craig Neill	M	Craig Neill	M	
	PMEL	Wenlin Huang	F			(PRC)
CFC/O_2	IOS	Carol Stewart	F	Carol Stewart	F	(NZ)
TALK	RSMAS	David Purkinson	M	Mary Roche	F	
	RSMAS	Jamie Goen	F	Jamie Goen	F	
	RSMAS	Chris Edwards	M	Xiarong Zhu	M	
pH	USF	Sean McElligott	M	Sean McElliogott	M	
	USF	Wensheng Yao	M	Wensheng Yao	M	
	USF	Johan Schijf	M	Xeuwu Liu	M	
U/W pCO_2	PMEL	Cathy Cosca	F			
DIC	PMEL	Marilyn Roberts	F			
				Kim Currie	F	(NZ)
	AOML	Tom Lantry	M	Tom Lantry	M	
pCO_2	PMEL	Dana Greeley	M	Dana Greeley	M	
	AOML	Hua Chen	M	Rhonda Kelly	F	
Primary Prod	UTK	Kendra Daly	F	Kendra Daly	F	
	USC	David Jones	M	David Jones	M	
	MBARI	Peter Walz	M	Tim Pennington	M	
DOC	BBSR	Susan Becker	F	Susan Becker	F	
	BBSR	Rachel Parsons	F	Rachel Parsons	F	
Carbon Isotop.	UW	Brian Kleinhaus	M	Tanya Westby	F	
Lowered ADCP	UH	Eric Firing	M			

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Station Locations: Leg 1

STATION NUMBER	Latitude	Longitude	Date	BOTTOM DEPTH (M)
1	45 49.5 S	153 05.1 E	6 Jan 96	4468
2	48 19.1 S	158 29.9 E	7 Jan 96	4850
3	50 05.0 S	162 29.3 E	8 Jan 96	4456
4	53 00.1 S	169 59.3 E	9 Jan 96	198
5	53 29.9 S	170 29.7 E	9 Jan 96	743
6	53 59.9 S	171 00.1 E	9 Jan 96	1175
7	54 10.2 S	171 10.8 E	9 Jan 96	1370
8	54 19.8 S	171 20.2 E	9 Jan 96	2615
9	54 30.3 S	171 29.8 E	9 Jan 96	4390
10	54 59.7 S	172 00.7 E	10 Jan 96	5345
11	55 30.4 S	172 27.0 E	10 Jan 96	5332
12	55 59.8 S	173 00.6 E	10 Jan 96	5415
13	56 29.2 S	173 30.2 E	11 Jan 96	5345
14	56 59.7 S	173 58.6 E	11 Jan 96	5430
15	57 30.3 S	173 58.5 E	11 Jan 96	5358
16	58 00.2 S	173 59.5 E	12 Jan 96	5205
17	58 30.2 S	173 58.2 E	12 Jan 96	5046
18	58 59.8 S	174 00.0 E	12 Jan 96	5110
19	59 28.7 S	173 59.7 E	12 Jan 96	5002
20	59 57.9 S	173 57.9 E	13 Jan 96	4346
21	60 30.3 S	173 57.8 E	13 Jan 96	5028
22	60 59.1 S	173 58.9 E	14 Jan 96	4712
23	61 30.0 S	174 00.2 E	14 Jan 96	5037
24	62 00.0 S	173 16.1 E	14 Jan 96	4450
25	62 26.9 S	172 35.2 E	14 Jan 96	4440
26	62 44.7 S	172 09.0 E	15 Jan 96	4450
27	62 60.0 S	171 44.9 E	15 Jan 96	2636
28	63 30.1 S	170 59.6 E	15 Jan 96	2422
29	63 59.8 S	171 06.6 E	16 Jan 96	2600
30	64 40.6 S	170 58.6 E	16 Jan 96	3475
31	65 20.2 S	170 60.0 E	16 Jan 96	3449
32	66 00.9 S	171 01.6 E	17 Jan 96	3151
33	66 59.6 S	170 00.0 W	18 Jan 96	3630
34	66 20.3 S	169 60.0 W	18 Jan 96	3430
35	65 39.8 S	170 00.3 W	19 Jan 96	3180
36	64 59.6 S	170 00.9 W	19 Jan 96	2880
37	64 30.1 S	169 59.9 W	19 Jan 96	2370
38	63 59.7 S	170 02.0 W	19 Jan 96	2783
39	63 30.1 S	170 00.3 W	20 Jan 96	2805
40	62 59.7 S	170 01.4 W	20 Jan 96	3085
41	62 30.0 S	169 59.8 W	20 Jan 96	2843
42	62 00.2 S	169 59.9 W	20 Jan 96	3422
43	61 29.5 S	169 60.0 W	21 Jan 96	3501
44	61 00.1 S	170 00.3 W	21 Jan 96	3630
45	60 29.7 S	169 59.6 W	22 Jan 96	3960
46	60 00.3 S	170 00.3 W	22 Jan 96	3738
47	59 30.2 S	169 59.9 W	22 Jan 96	4030
48	58 59.9 S	170 00.2 W	22 Jan 96	4780
49	58 29.6 S	170 00.8 W	23 Jan 96	5188
50	57 59.7 S	170 00.8 W	23 Jan 96	4140
51	57 30.1 S	170 00.4 W	23 Jan 96	5001
52	57 00.2 S	170 00.2 W	24 Jan 96	5165

Station Locations: Leg 1 *(continued)*

STATION NUMBER	Latitude	Longitude	Date	BOTTOM DEPTH (M)
53	56 29.9 S	169 59.8 W	24 Jan 96	5055
54	55 60.0 S	170 01.8 W	24 Jan 96	5157
55	55 29.9 S	170 00.0 W	24 Jan 96	4950
56	54 59.8 S	169 60.0 W	25 Jan 96	4820
57	54 29.4 S	170 00.1 W	25 Jan 96	4819
58	54 00.1 S	169 59.3 W	25 Jan 96	5013
59	53 39.9 S	169 59.4 W	25 Jan 96	5125
60	53 19.9 S	169 59.6 W	26 Jan 96	5276
61	52 60.0 S	170 00.5 W	26 Jan 96	5185
62	52 29.9 S	170 01.8 W	26 Jan 96	5065
63	52 00.1 S	170 07.8 W	26 Jan 96	4968
64	51 30.0 S	170 00.2 W	27 Jan 96	4757
65	51 00.2 S	170 00.4 W	27 Jan 96	5239
66	50 29.9 S	169 59.6 W	27 Jan 96	5041
67	50 00.4 S	169 59.9 W	28 Jan 96	5340
68	49 30.2 S	170 00.9 W	28 Jan 96	5200
69	48 59.6 S	169 59.4 W	28 Jan 96	5235
70	48 30.0 S	170 00.2 W	28 Jan 96	5280
71	47 59.8 S	170 00.3 W	29 Jan 96	5270
72	47 30.2 S	169 59.8 W	29 Jan 96	5285
73	47 06.5 S	170 27.7 W	29 Jan 96	5365
74	46 43.4 S	170 54.7 W	30 Jan 96	5268
75	46 20.0 S	171 22.2 W	30 Jan 96	5083
76	45 57.0 S	171 49.5 W	30 Jan 96	5136
77	45 33.6 S	172 16.7 W	30 Jan 96	4953
78	45 10.6 S	172 44.2 W	31 Jan 96	4652
79	44 50.1 S	173 08.2 W	31 Jan 96	3838
80	44 31.8 S	173 29.4 W	31 Jan 96	3408
81	44 19.2 S	173 44.7 W	31 Jan 96	3090
82	44 09.4 S	173 56.3 W	1 Feb 96	1908
83	43 50.9 S	174 17.7 W	1 Feb 96	950
84	43 38.8 S	174 32.2 W	1 Feb 96	790
85	43 15.2 S	174 59.9 W	1 Feb 96	790
86	42 55.9 S	174 47.2 W	1 Feb 96	1059
87	42 44.8 S	174 39.3 W	1 Feb 96	1590
88	42 24.1 S	174 24.4 W	1 Feb 96	2668
89	42 10.0 S	174 15.0 W	2 Feb 96	2875
90	41 42.8 S	173 56.5 W	2 Feb 96	3130
91	41 16.0 S	173 38.6 W	2 Feb 96	3330
92	40 49.5 S	173 19.5 W	2 Feb 96	4170
93	40 23.6 S	173 02.0 W	2 Feb 96	4568

Station Locations: Leg 2

STATION NUMBER	Latitude	Longitude	Date	BOTTOM DEPTH (M)
94	40 23.5 S	173 01.7 W	13 Feb 96	4568
95	39 57.7 S	172 42.2 W	14 Feb 96	4728
96	39 31.0 S	172 25.2 W	14 Feb 96	4751
97	39 04.3 S	172 07.7 W	14 Feb 96	4836
98	38 37.8 S	171 48.6 W	14 Feb 96	4901
99	38 11.4 S	171 30.2 W	15 Feb 96	4918
100	37 45.8 S	171 12.0 W	15 Feb 96	4980
101	37 18.6 S	170 53.7 W	15 Feb 96	5112
102	36 52.3 S	170 37.0 W	15 Feb 96	5254
103	36 27.0 S	170 17.2 W	16 Feb 96	5102
104	36 00.2 S	170 00.3 W	16 Feb 96	5050
105	35 40.3 S	170 00.9 W	16 Feb 96	4290
106	35 20.0 S	170 00.1 W	16 Feb 96	4880
107	35 00.5 S	169 59.6 W	17 Feb 96	5226
108	34 30.2 S	170 00.2 W	17 Feb 96	5457
109	33 59.8 S	169 60.0 W	17 Feb 96	5501
110	33 29.9 S	170 00.1 W	18 Feb 96	5387
111	33 00.1 S	170 00.1 W	18 Feb 96	5548
112	32 30.1 S	170 00.1 W	18 Feb 96	5501
113	31 59.8 S	169 59.8 W	18 Feb 96	5640
114	31 30.0 S	169 59.3 W	19 Feb 96	5496
115	31 00.4 S	169 59.7 W	19 Feb 96	5572
116	30 30.3 S	169 59.8 W	19 Feb 96	5505
117	30 00.2 S	169 59.8 W	19 Feb 96	5394
118	29 30.2 S	169 59.8 W	20 Feb 96	5127
119	29 00.8 S	169 59.9 W	20 Feb 96	5562
120	28 30.5 S	169 59.8 W	20 Feb 96	5425
121	28 00.3 S	169 59.6 W	21 Feb 96	4888
122	27 30.1 S	170 00.1 W	21 Feb 96	5318
123	27 00.3 S	169 59.5 W	21 Feb 96	5214
124	26 29.7 S	169 59.4 W	21 Feb 96	5575
125	26 00.3 S	169 59.7 W	22 Feb 96	5563
126	25 30.0 S	169 60.0 W	22 Feb 96	5787
127	25 00.1 S	169 59.9 W	22 Feb 96	5600
128	24 30.1 S	170 00.1 W	23 Feb 96	5610
129	23 59.8 S	170 00.1 W	23 Feb 96	5637
130	23 30.1 S	170 00.1 W	23 Feb 96	5626
131	22 59.8 S	169 59.7 W	23 Feb 96	5650
132	22 30.0 S	169 59.9 W	24 Feb 96	5609
133	22 00.0 S	169 59.9 W	24 Feb 96	5587
134	21 30.4 S	170 00.1 W	24 Feb 96	5388
135	20 59.7 S	169 59.6 W	25 Feb 96	5427
136	20 29.9 S	170 00.1 W	25 Feb 96	5560
137	20 00.0 S	170 00.1 W	25 Feb 96	5294
138	19 29.9 S	170 00.1 W	25 Feb 96	4885
139	19 00.1 S	170 03.4 W	26 Feb 96	3000
140	18 30.3 S	170 00.1 W	26 Feb 96	5232
141	17 60.0 S	169 60.0 W	26 Feb 96	4893
142	17 30.1 S	169 60.0 W	26 Feb 96	5002
143	17 00.1 S	169 59.8 W	27 Feb 96	4954
144	16 30.3 S	169 59.9 W	27 Feb 96	5109
145	16 00.2 S	169 59.9 W	27 Feb 96	5120

Station Locations: Leg 2 *(continued)*

STATION NUMBER	Latitude	Longitude	Date	BOTTOM DEPTH (M)
146	15 29.8 S	170 00.1 W	27 Feb 96	5064
147	15 00.2 S	170 00.0 W	28 Feb 96	4803
148	14 40.0 S	169 59.9 W	28 Feb 96	3322
149	14 16.9 S	169 59.8 W	28 Feb 96	3540
150	13 58.3 S	169 60.0 W	28 Feb 96	2947
151	13 49.1 S	170 00.1 W	28 Feb 96	4297
152	13 30.1 S	169 60.0 W	29 Feb 96	4860
153	12 59.9 S	170 00.0 W	29 Feb 96	4949
154	12 29.9 S	169 59.9 W	29 Feb 96	4979
155	12 00.1 S	170 00.1 W	29 Feb 96	5055
156	11 30.0 S	169 59.9 W	1 Mar 96	5035
157	11 00.1 S	169 59.9 W	1 Mar 96	5100
158	10 30.1 S	169 59.8 W	1 Mar 96	4858
159	09 55.6 S	169 37.7 W	1 Mar 96	5179
160	09 30.1 S	168 59.9 W	2 Mar 96	5310
161	08 59.9 S	168 52.6 W	2 Mar 96	4848
162	08 29.9 S	168 44.9 W	2 Mar 96	5129
163	08 00.0 S	168 37.0 W	2 Mar 96	5138
164	07 30.1 S	168 44.9 W	3 Mar 96	5244
165	06 60.0 S	168 44.9 W	3 Mar 96	5628
166	06 30.1 S	168 44.9 W	3 Mar 96	5498
167	06 00.0 S	168 45.0 W	4 Mar 96	5629
168	05 30.1 S	168 45.0 W	4 Mar 96	5347
169	05 00.0 S	168 44.9 W	4 Mar 96	5534
170	03 60.0 S	168 45.1 W	4 Mar 96	5191
171	03 00.0 S	168 45.0 W	5 Mar 96	5347
172	02 00.1 S	168 45.0 W	5 Mar 96	3293
173	01 00.1 S	168 45.2 W	6 Mar 96	5748
174	00 00.1 S	168 45.0 W	6 Mar 96	5542
175	07 44.8 S	168 40.2 W	8 Mar 96	5289
176	08 15.1 S	168 41.3 W	8 Mar 96	4944
177	10 08.7 S	168 58.8 W	8 Mar 96	4628
178	10 04.1 S	169 12.7 W	8 Mar 96	5226
179	09 55.2 S	169 37.7 W	9 Mar 96	5188
180	09 47.0 S	170 03.5 W	9 Mar 96	4993
181	09 41.6 S	170 19.5 W	9 Mar 96	4297
182	09 35.7 S	170 36.1 W	9 Mar 96	4038

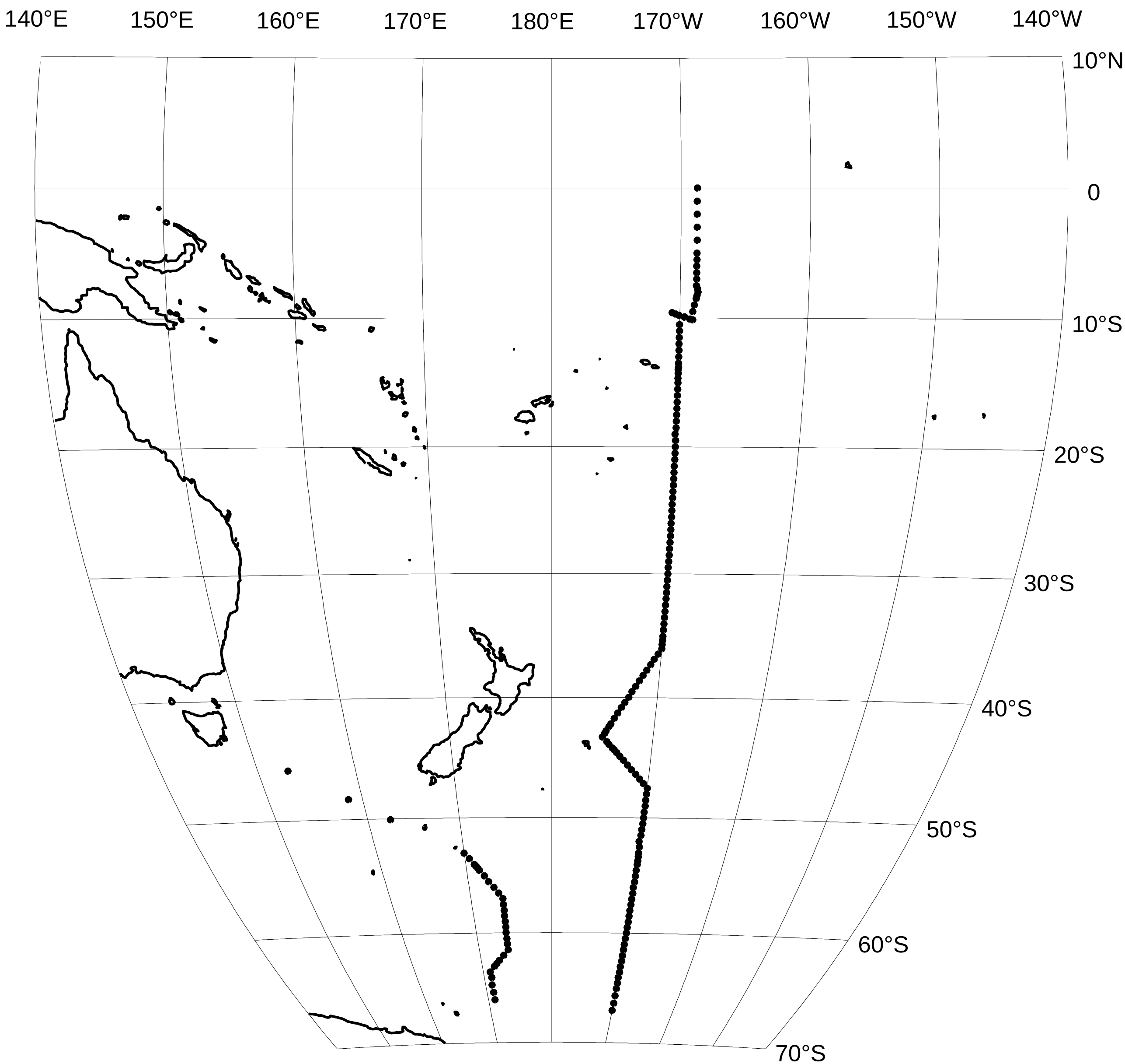

Figure 1: P14S and P15S (CGC96) Station Locations

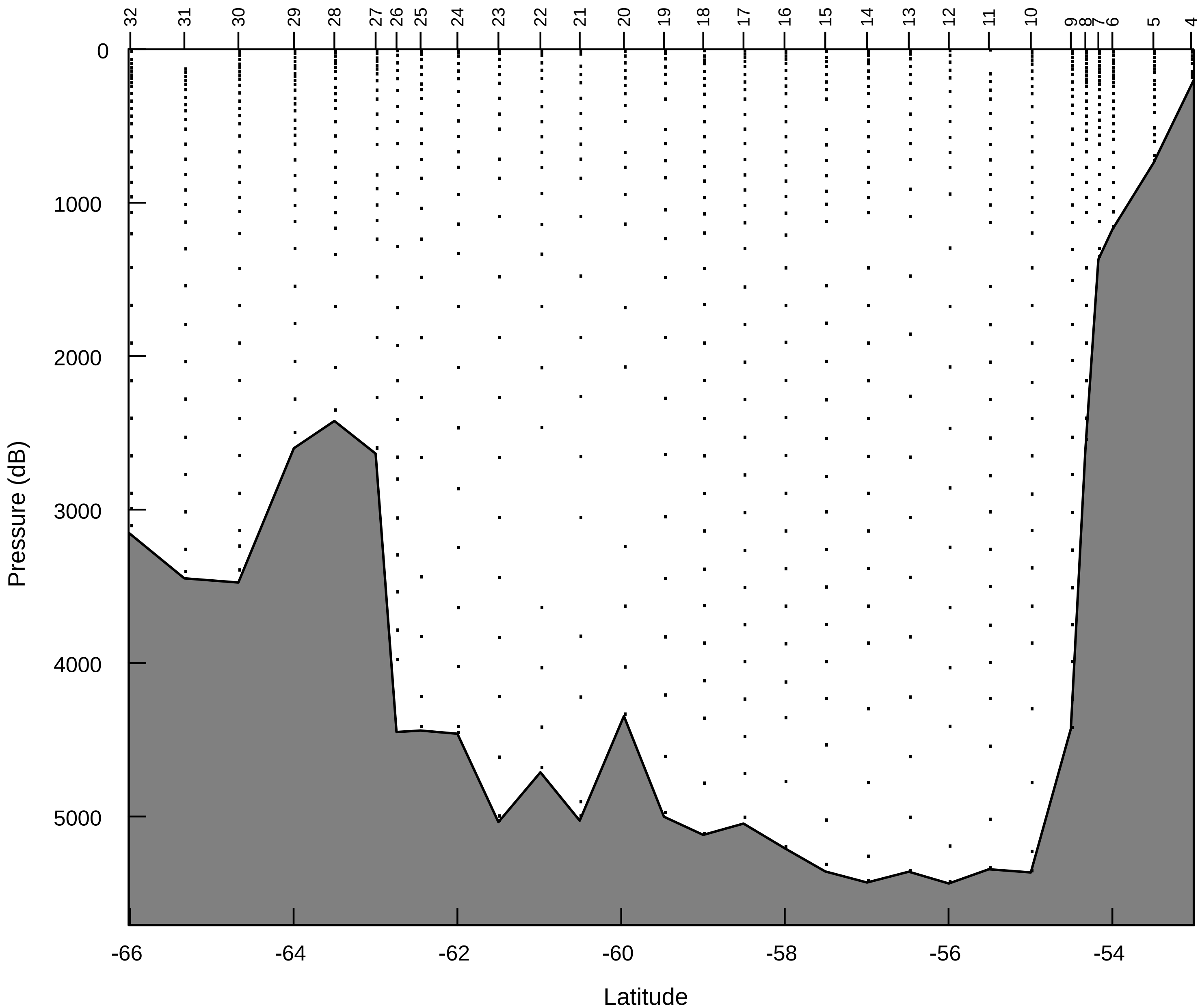

Figure 2a: Bottle Sample Locations on P14S

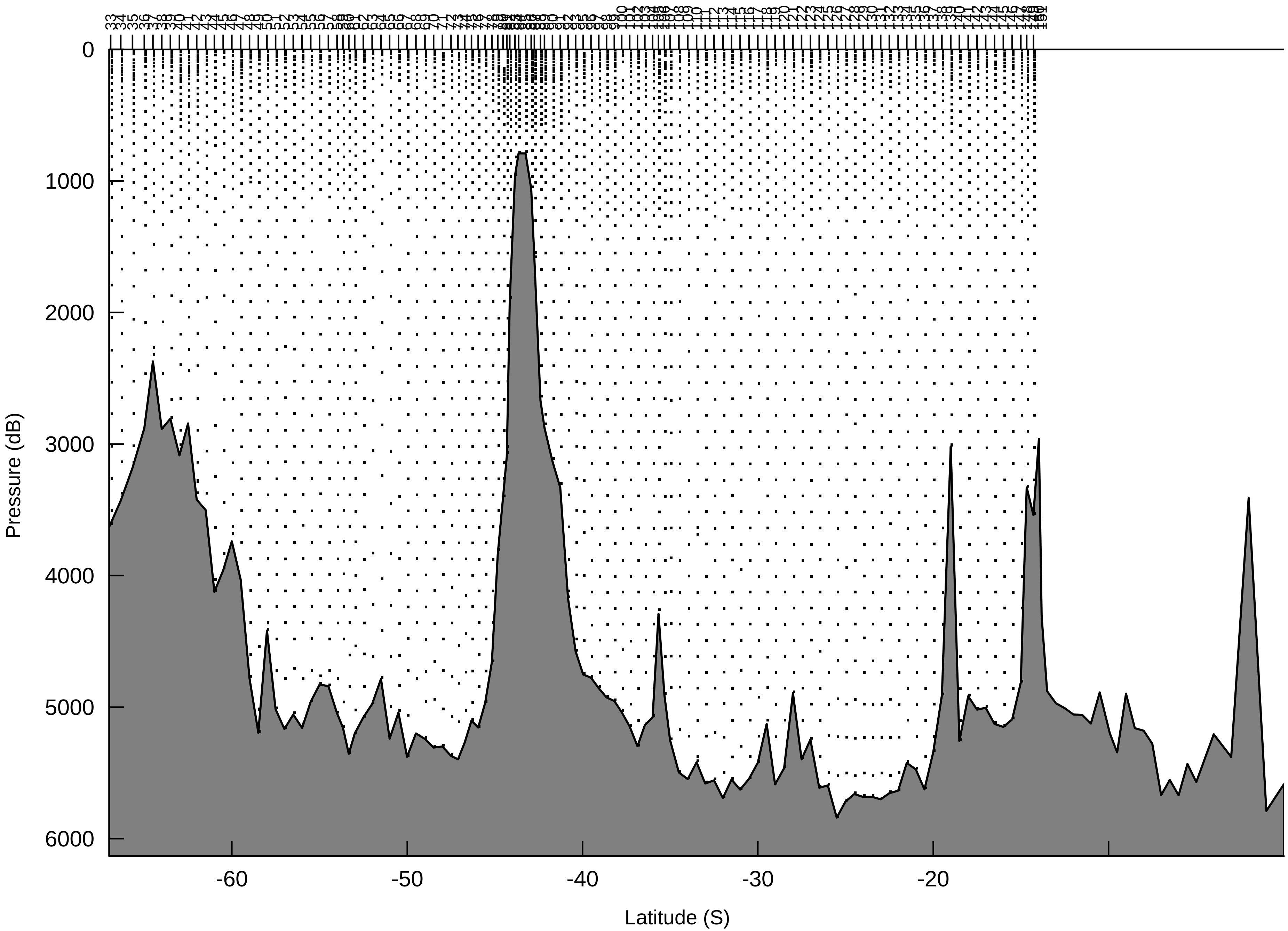

Figure 2b: Bottle Sample Locations on P15S

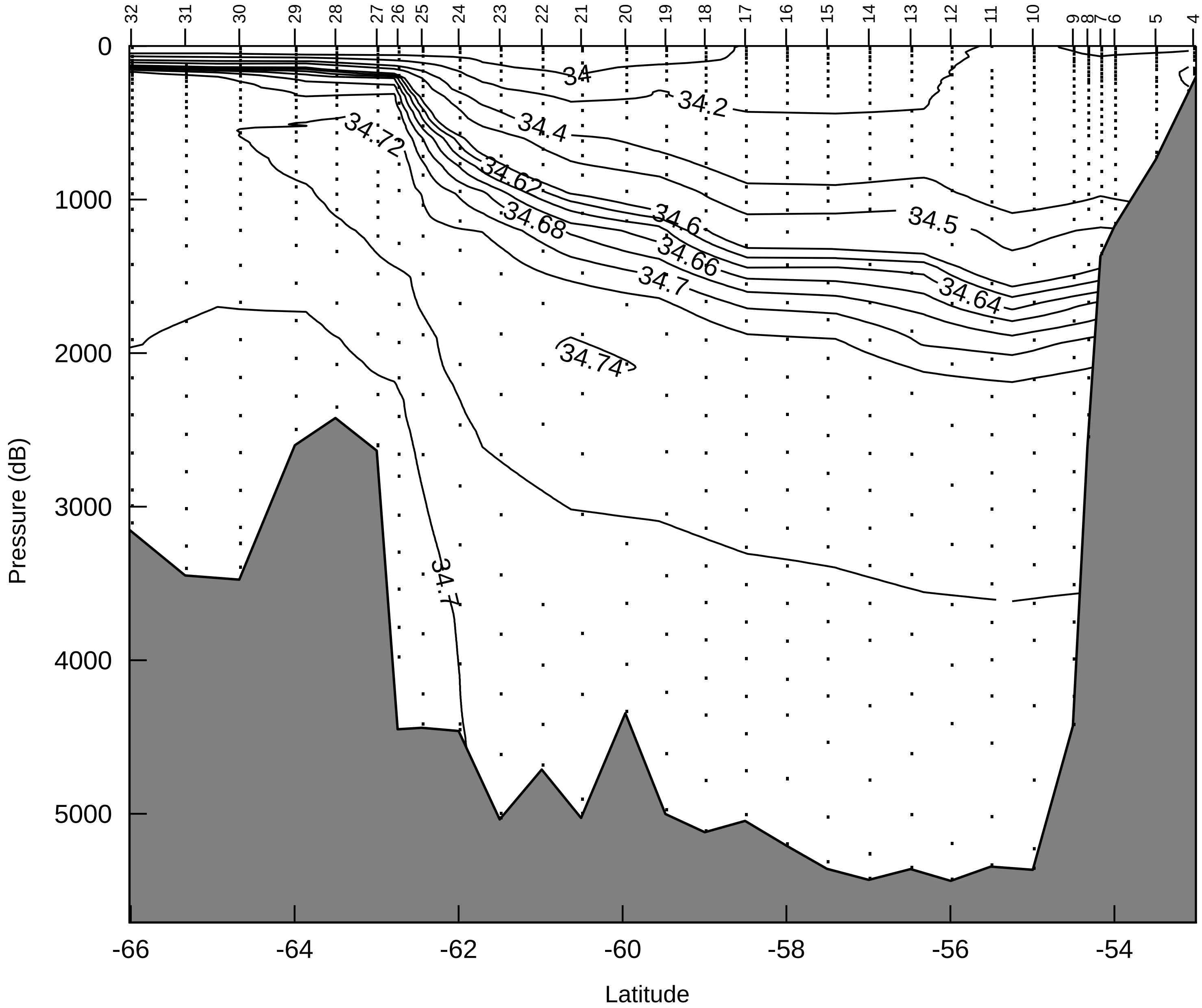

Figure 3a: Salinity Section along P14S (Preliminary)

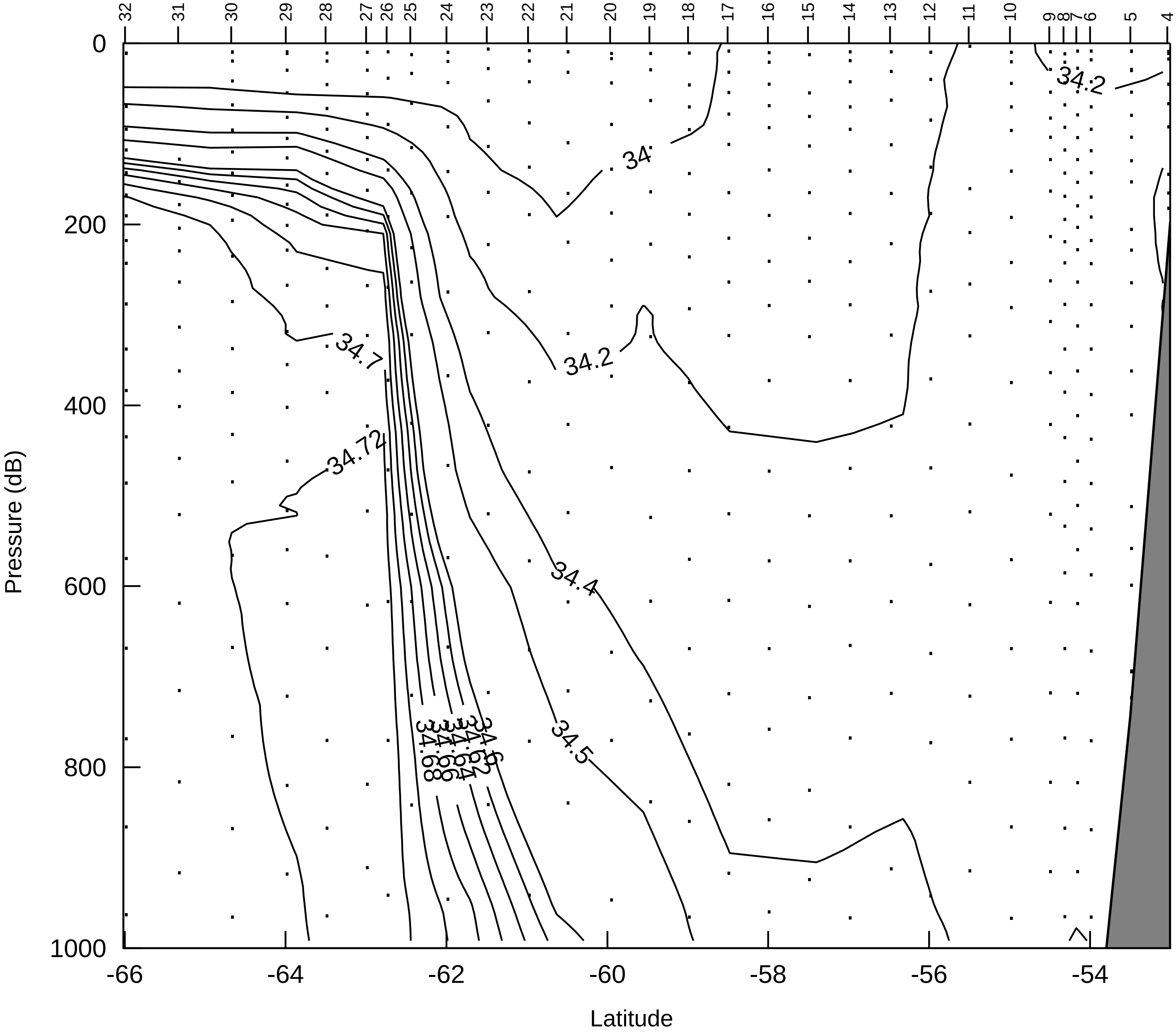

Figure 3b: Salinity Section along P14S (Preliminary)

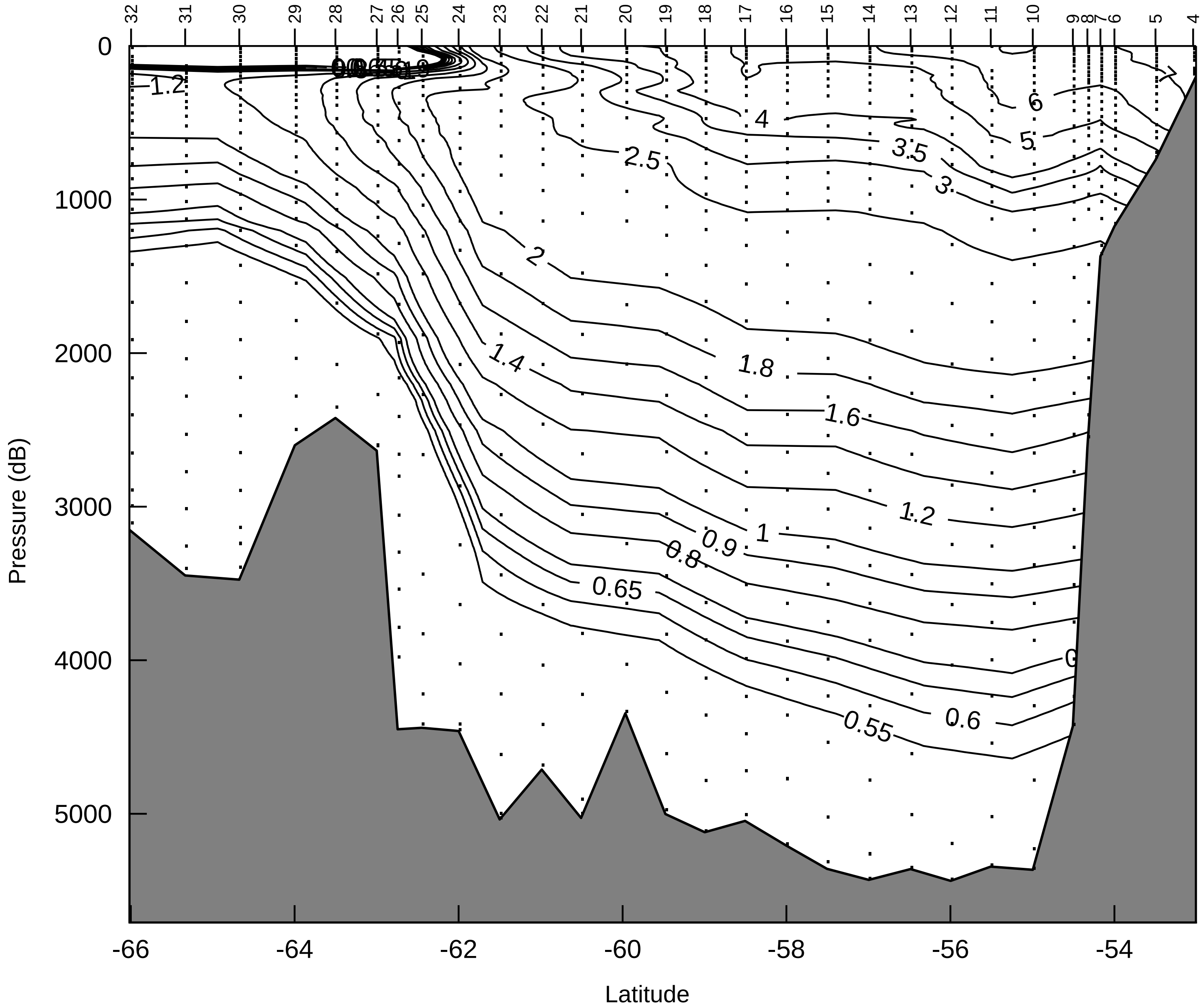

Figure 4a: Potential Temperature Section along P14S (Preliminary)

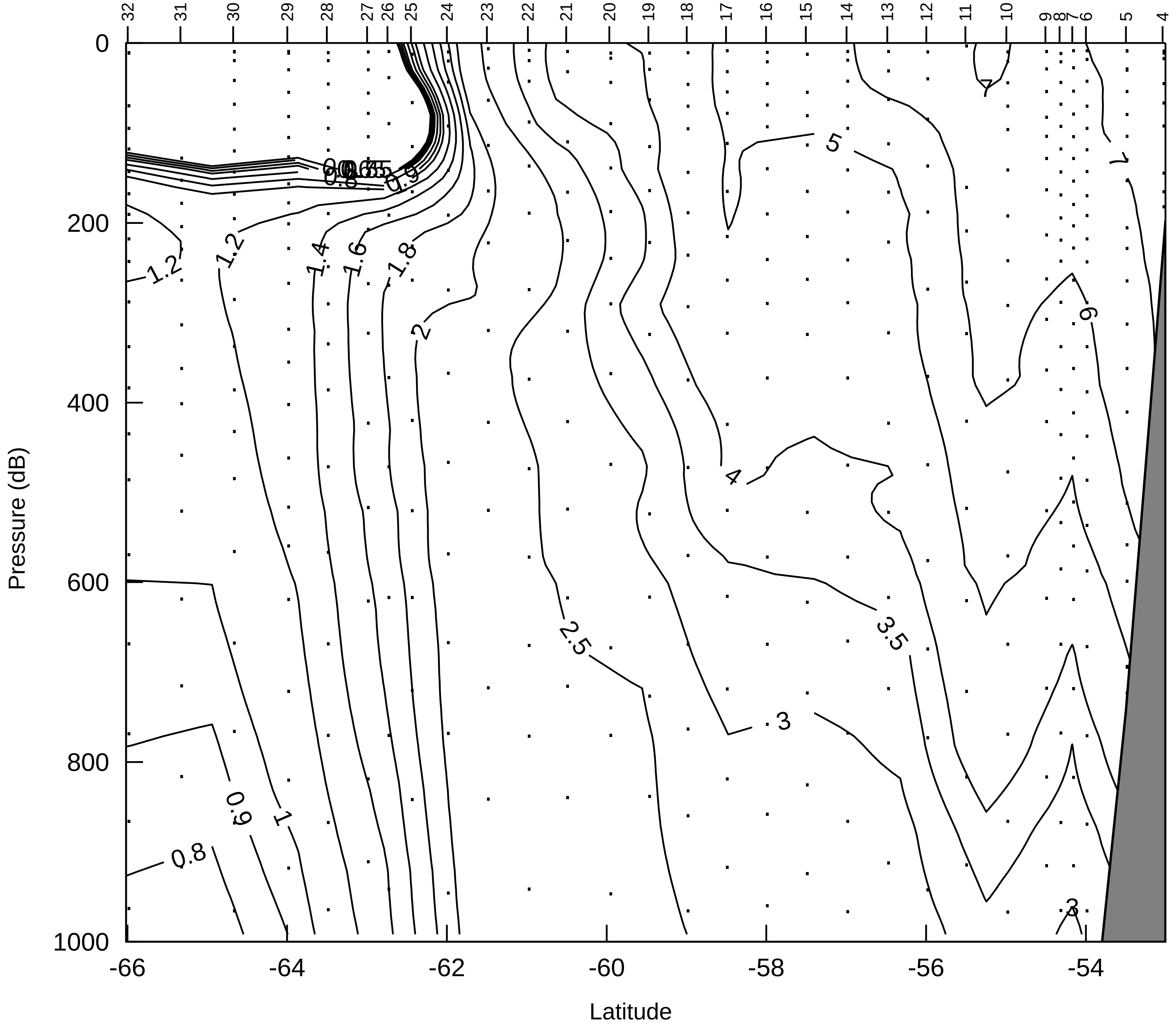

Figure 4b: Potential Temperature Section along P14S (Preliminary)

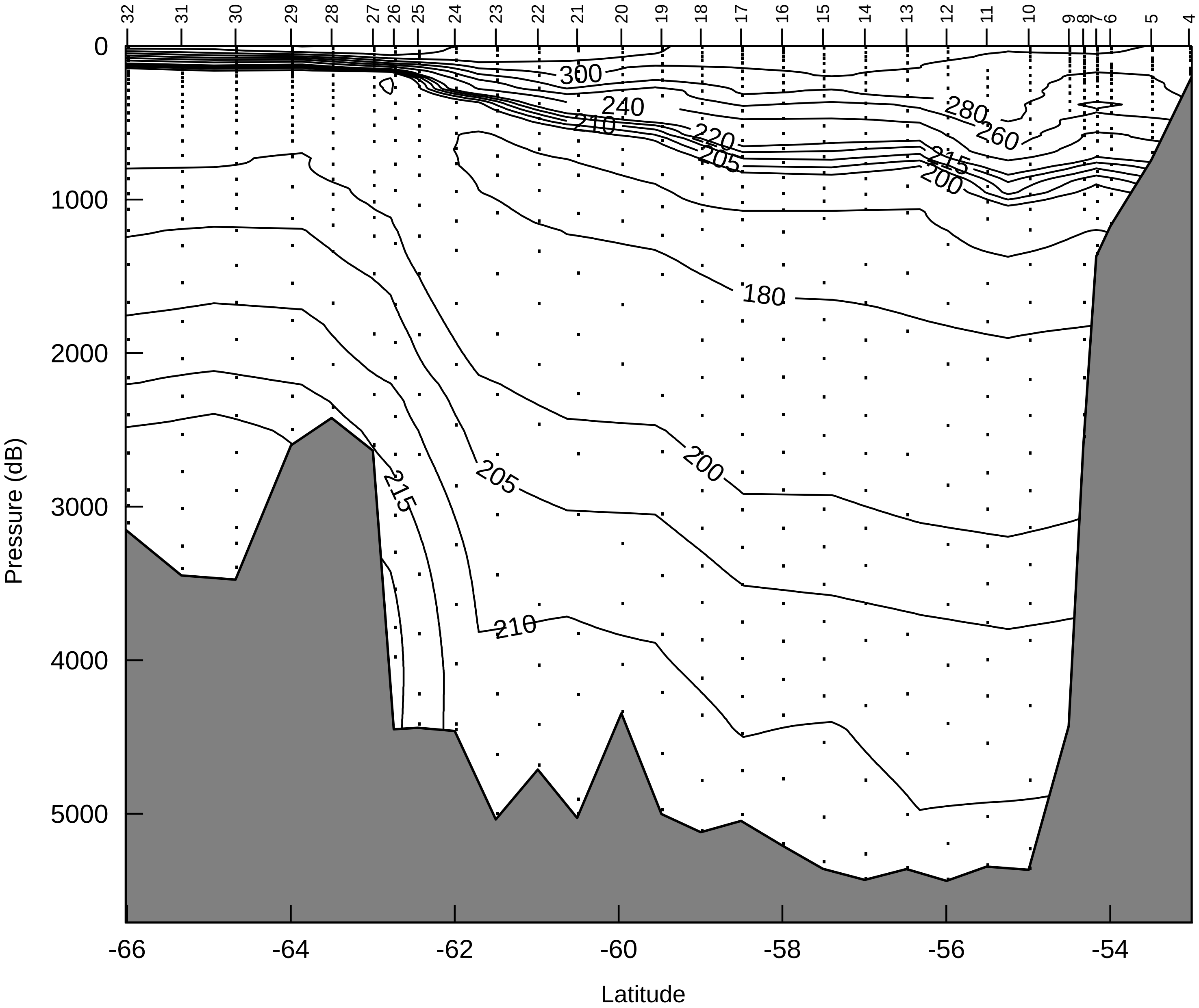

Figure 5a: Oxygen (µmol/kg) Section along P14S (Preliminary)

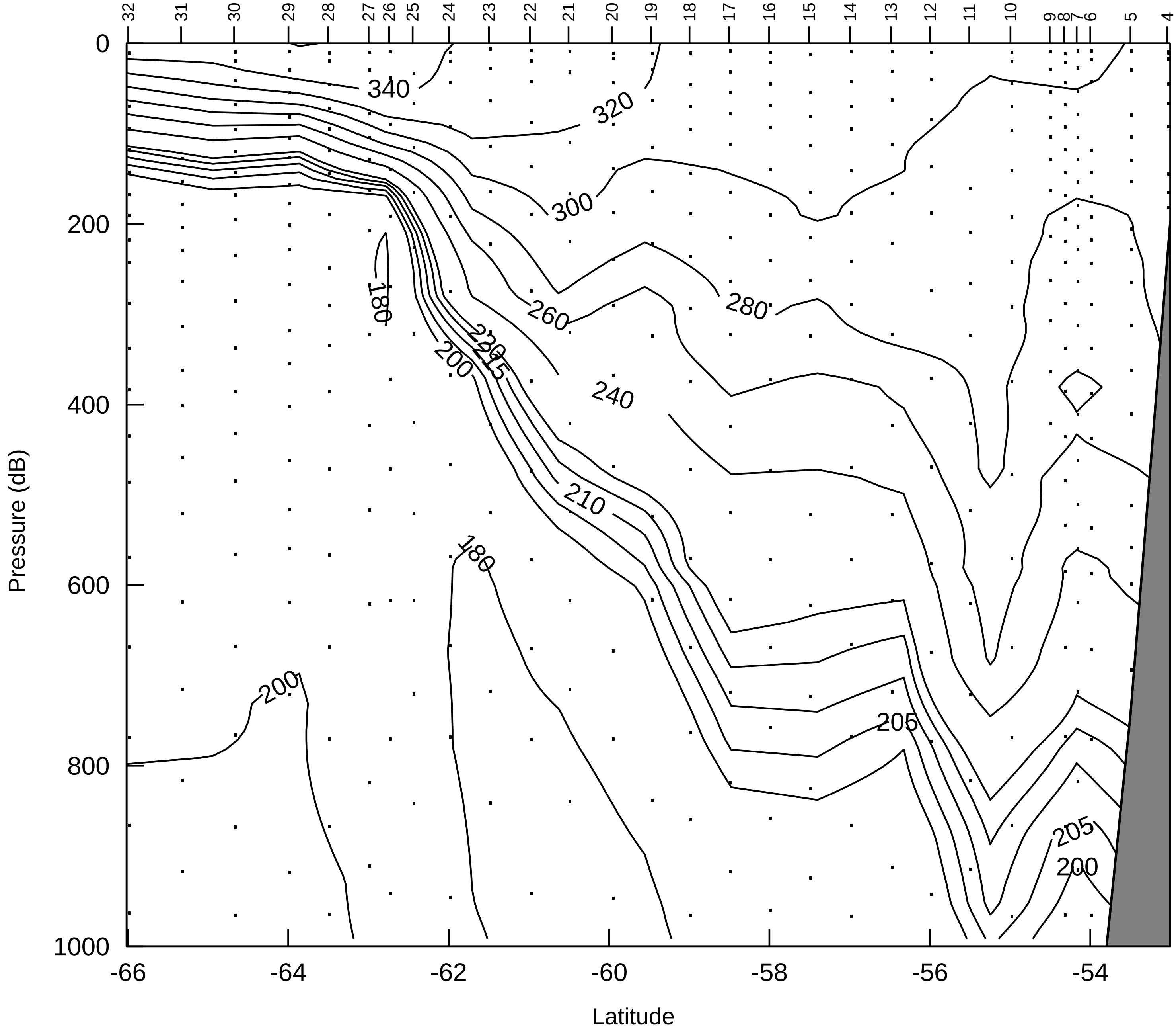

Figure 5b: Oxygen (umol/kg) Section along P14S (Preliminary)

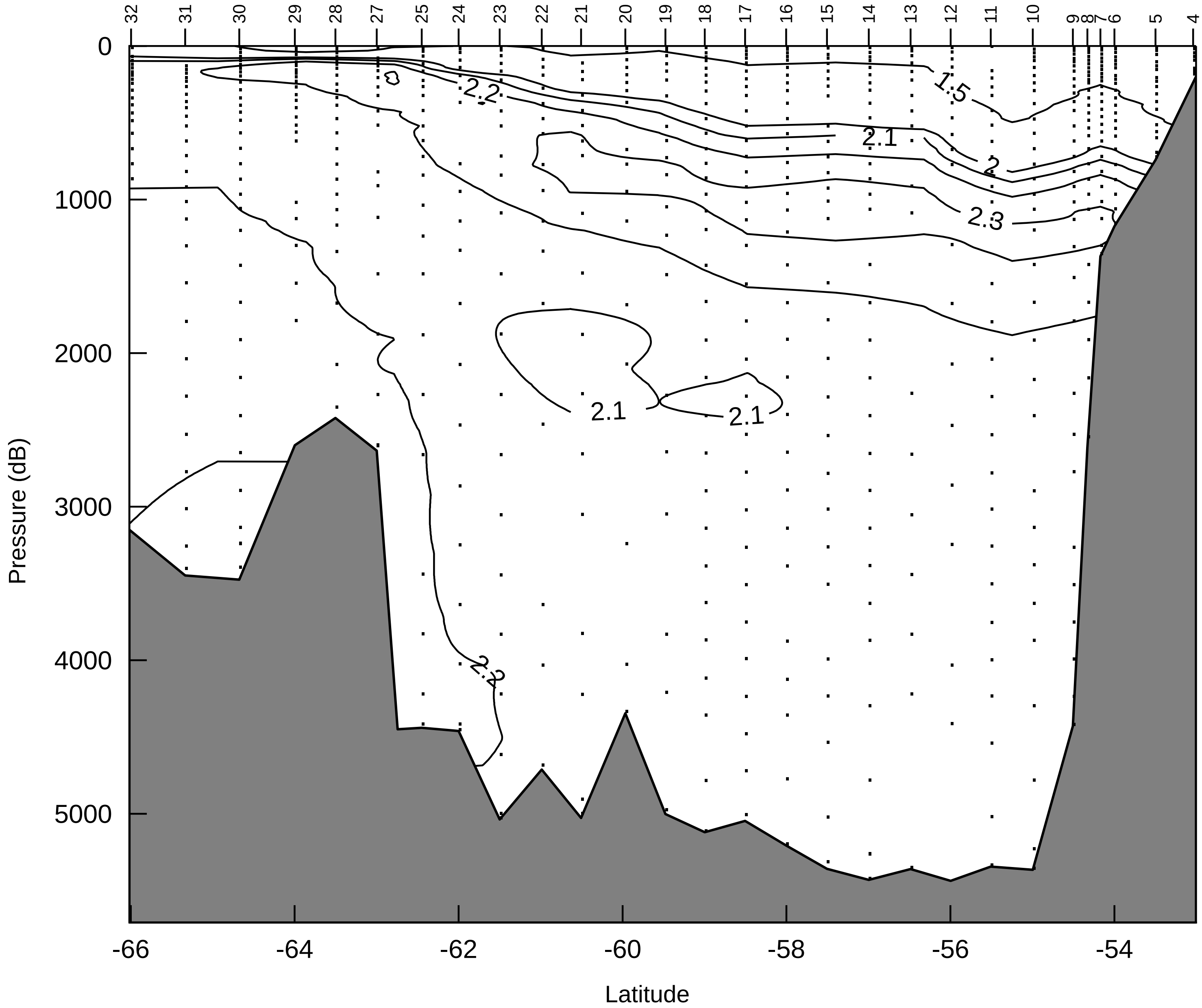

Figure 6a: Phosphate (µmol/kg) Section along P14S (Preliminary)

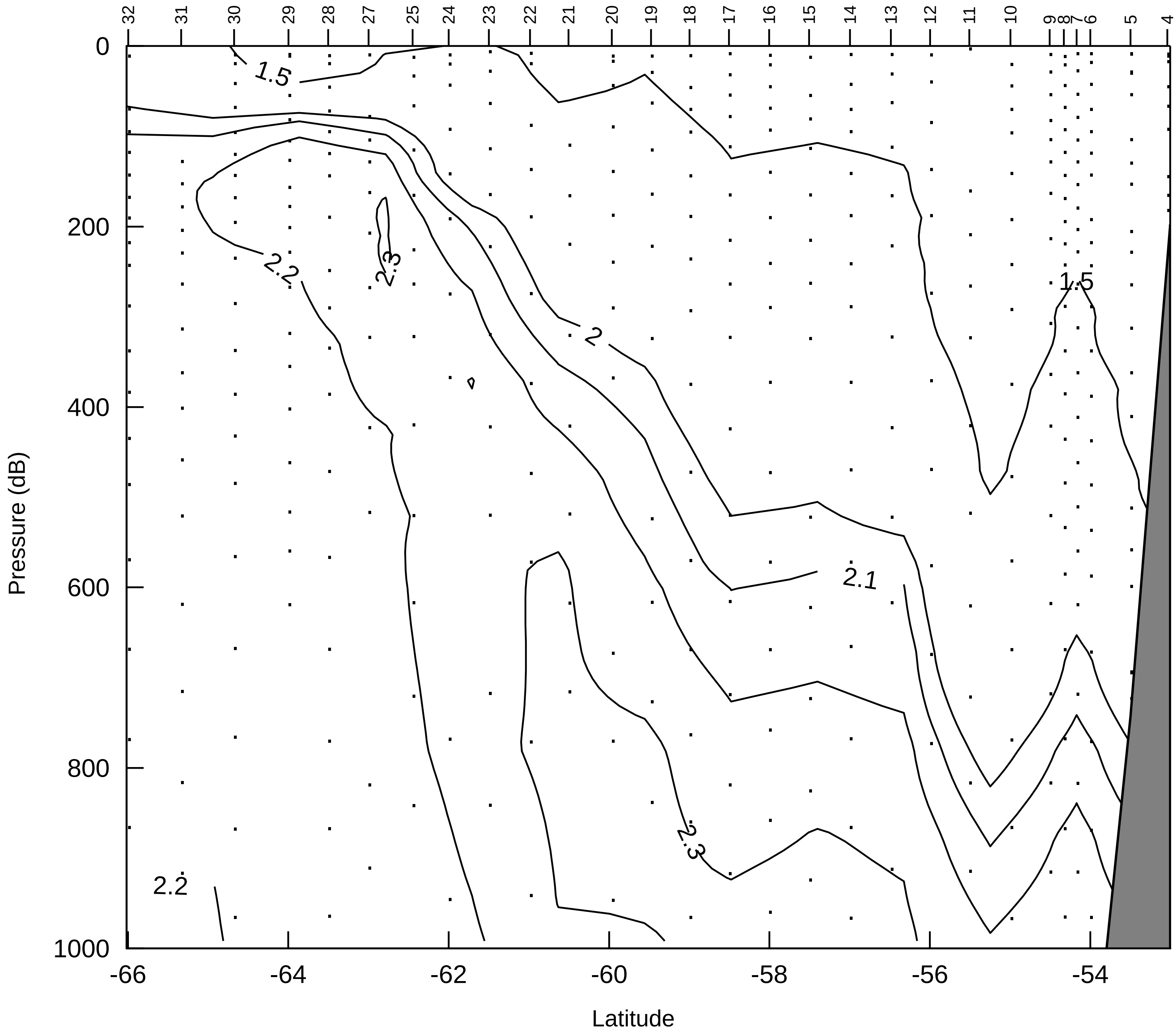

Figure 6b: Phosphate (µmol/kg) Section along P14S (Preliminary)

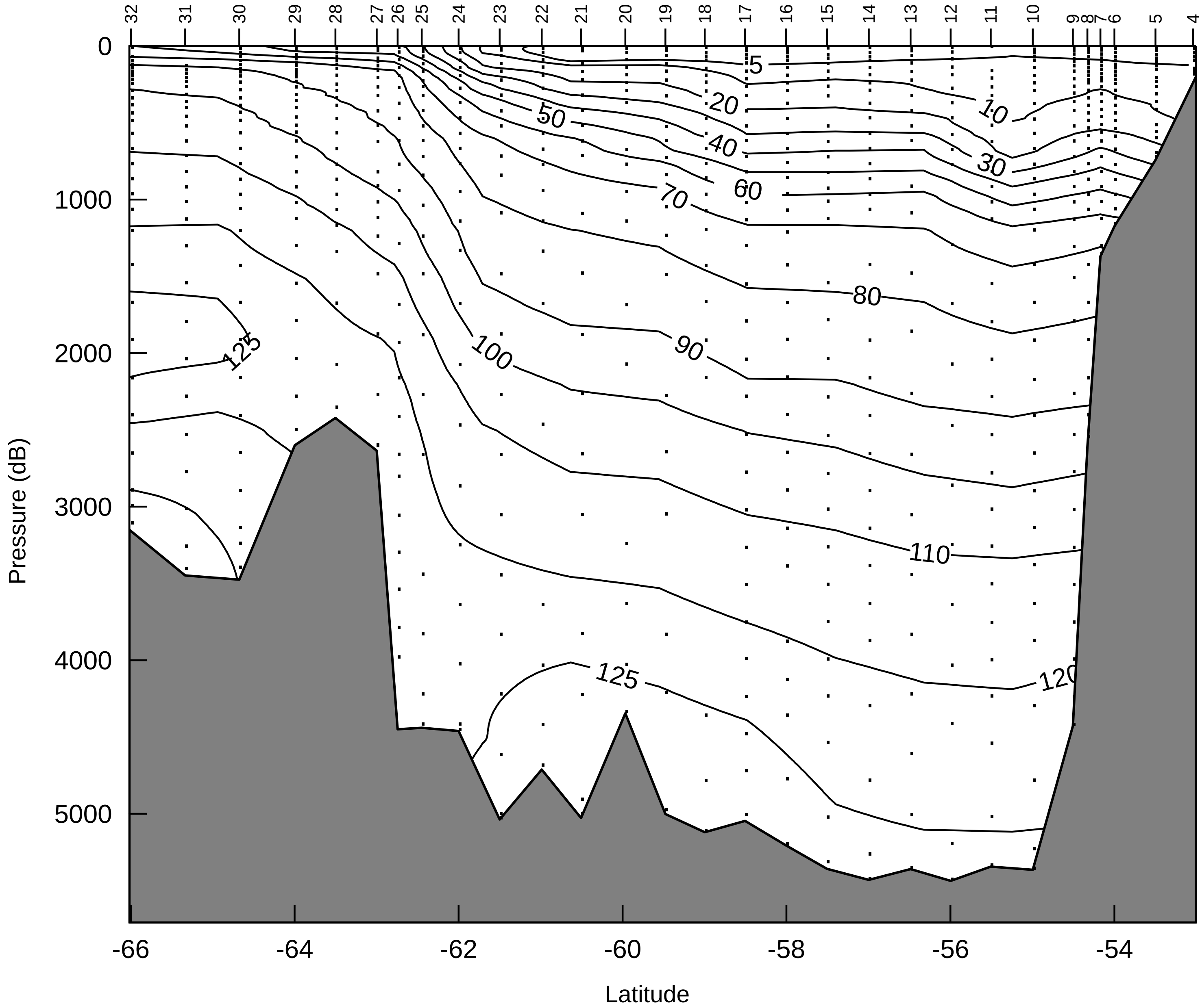

Figure 7a: Silicate (µmol/kg) Section along P14S (Preliminary)

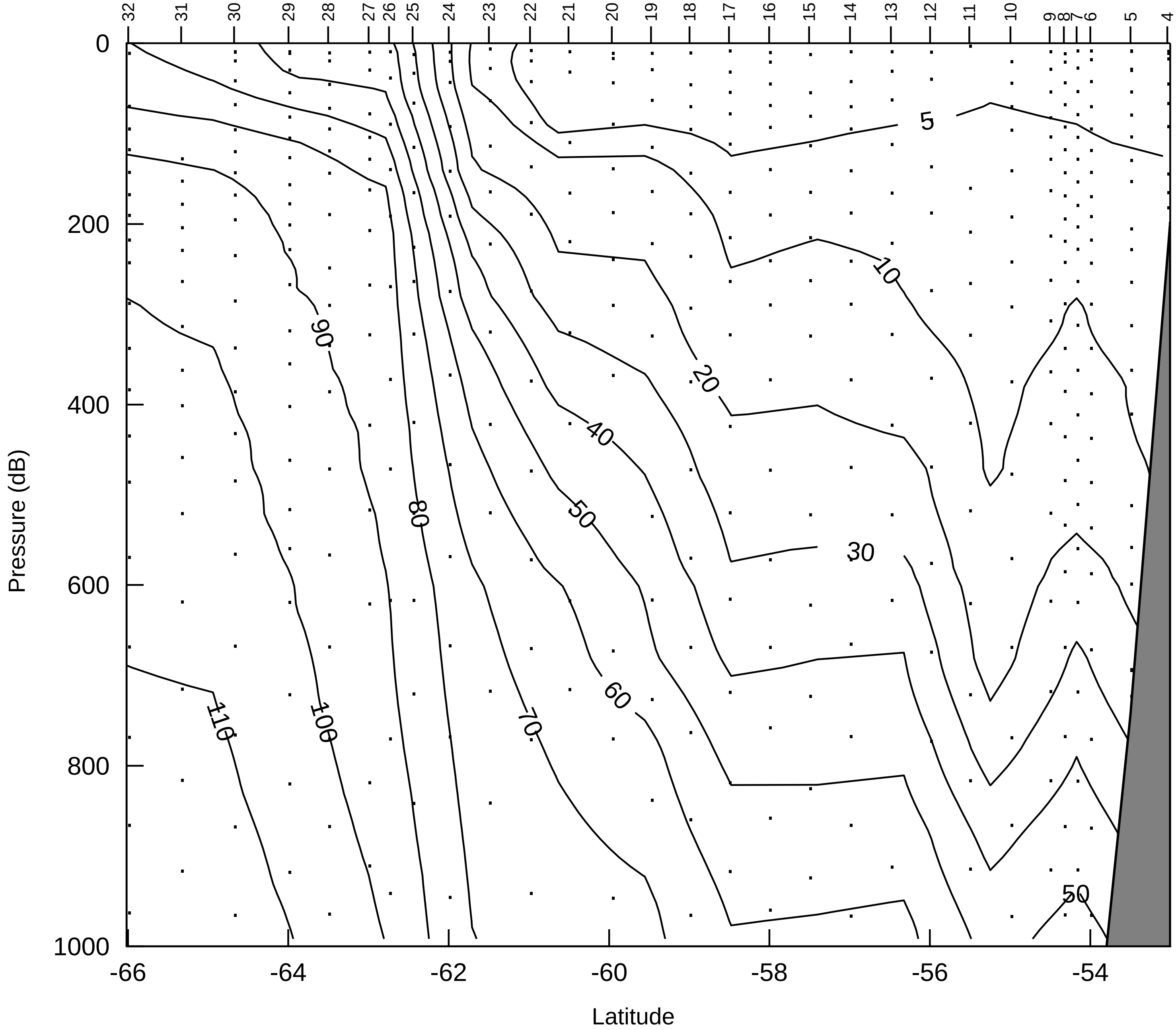

Figure 7b: Silicate (µmol/kg) Section along P14S (Preliminary)

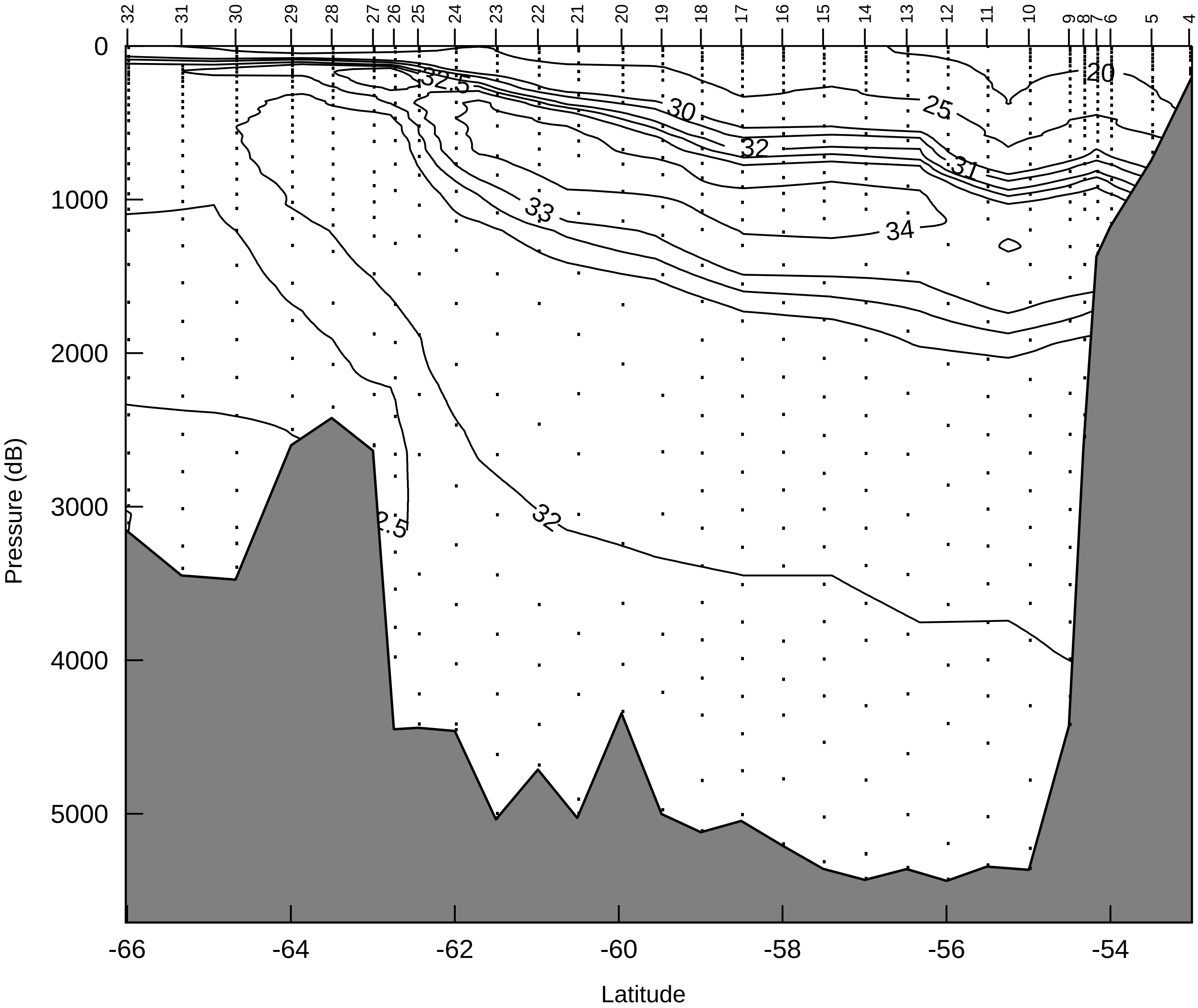

Figure 8a: Nitrate (µmol/kg) Section along P14S (Preliminary)

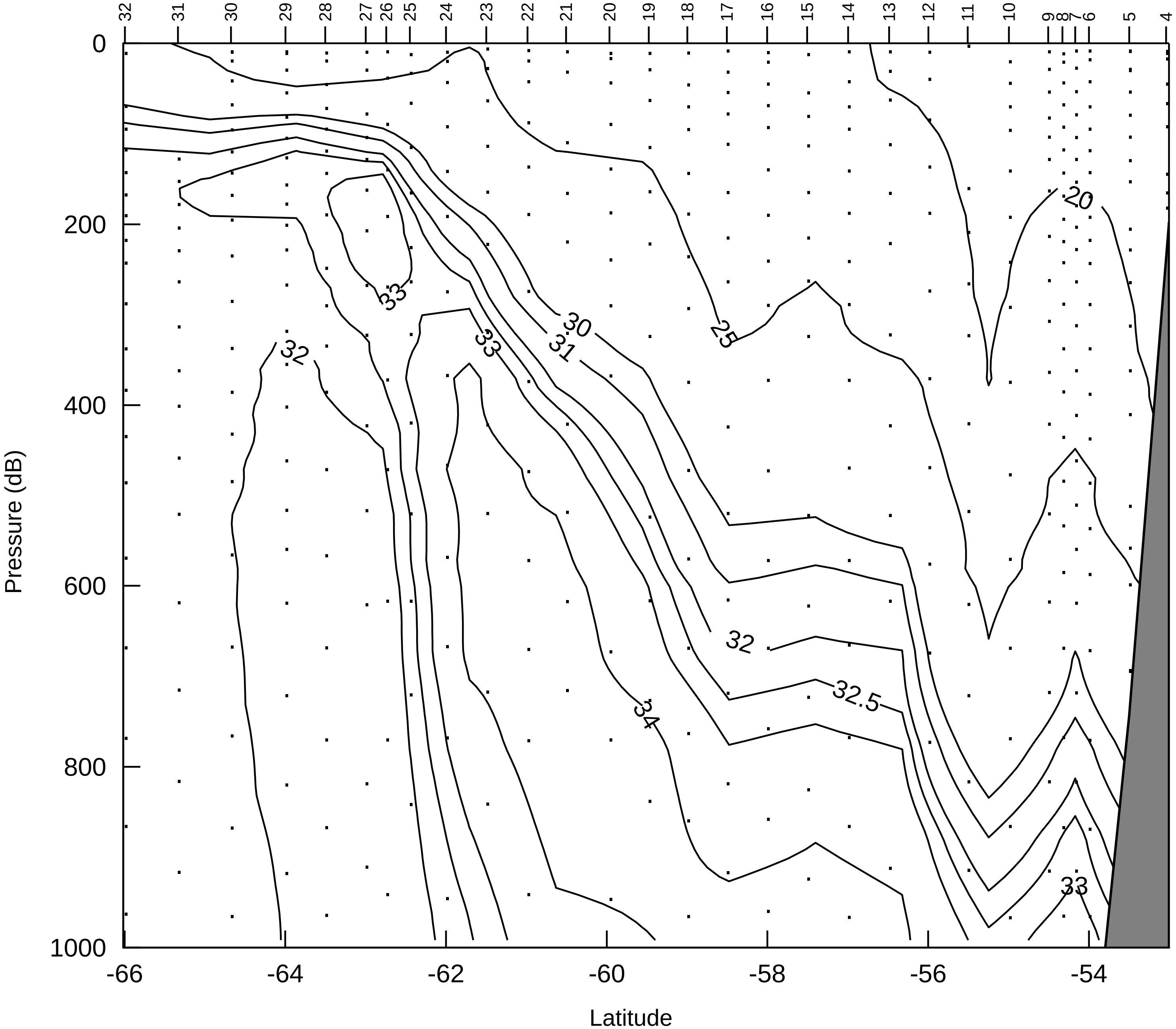

Figure 8b: Nitrate (μmol/kg) Section along P14S (Preliminary)

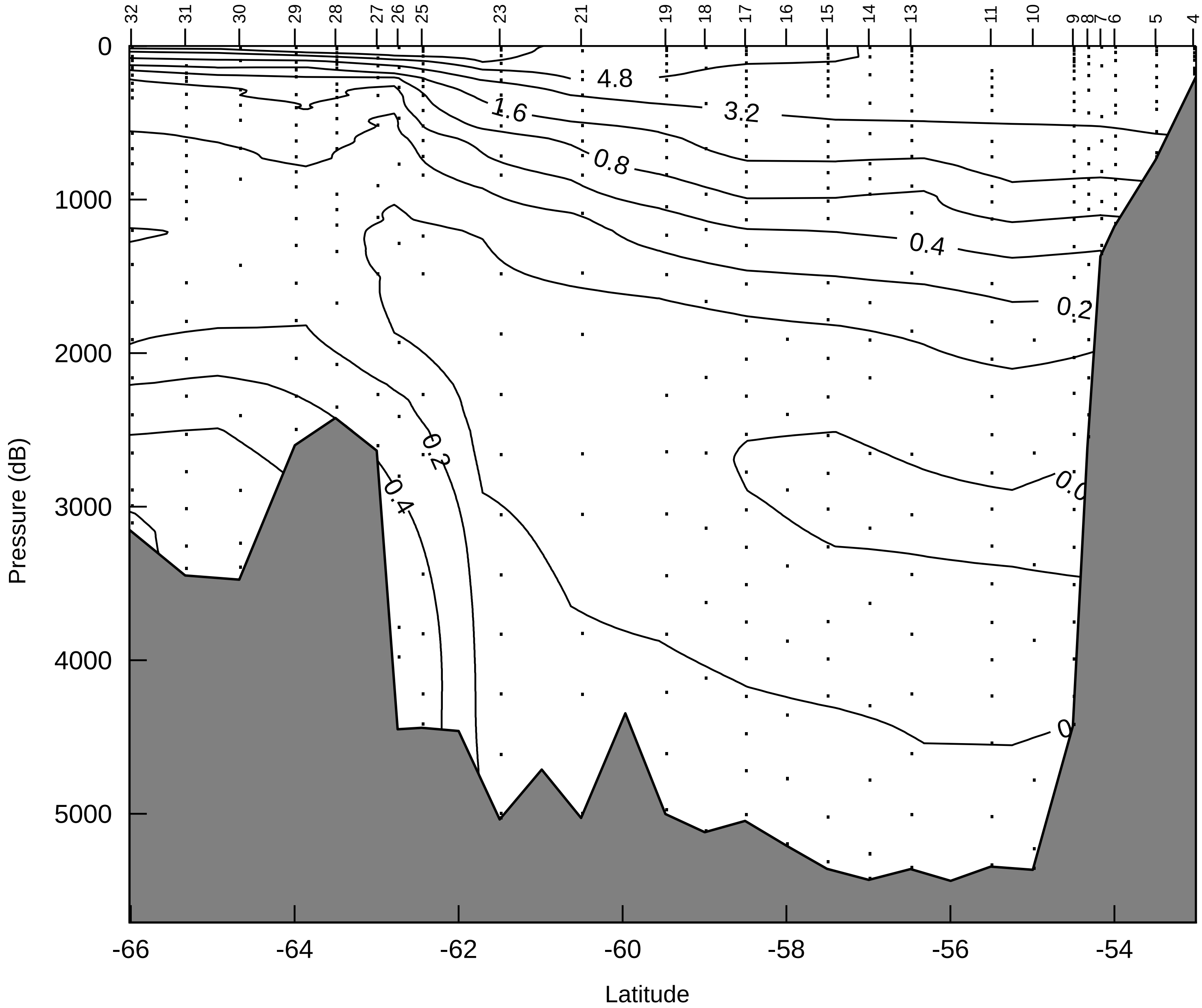

Figure 9a: CFC-11 (pmol/kg) Section along P14S (Preliminary)

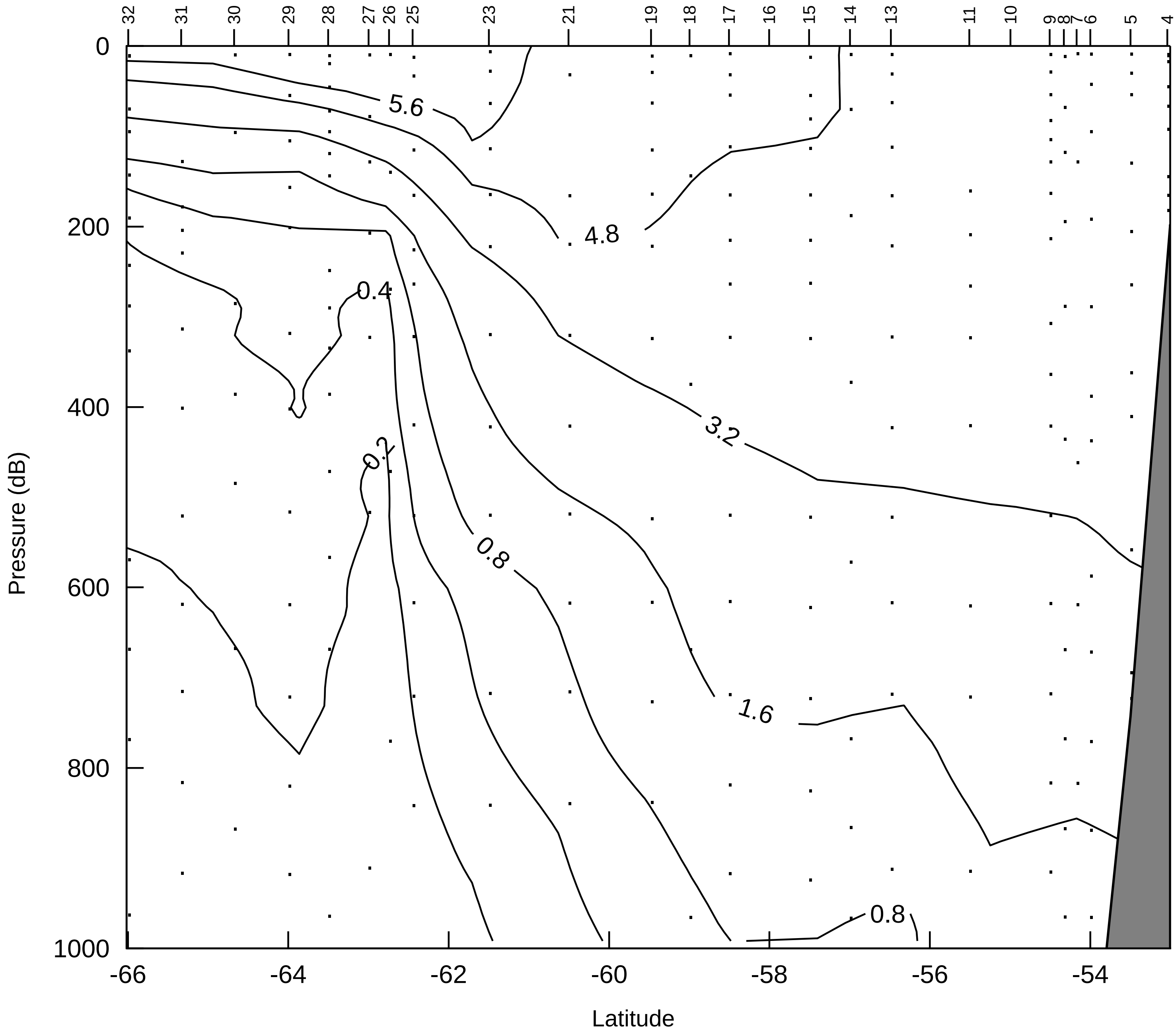

Figure 9b: CFC-11 (pmol/kg) Section along P14S (Preliminary)

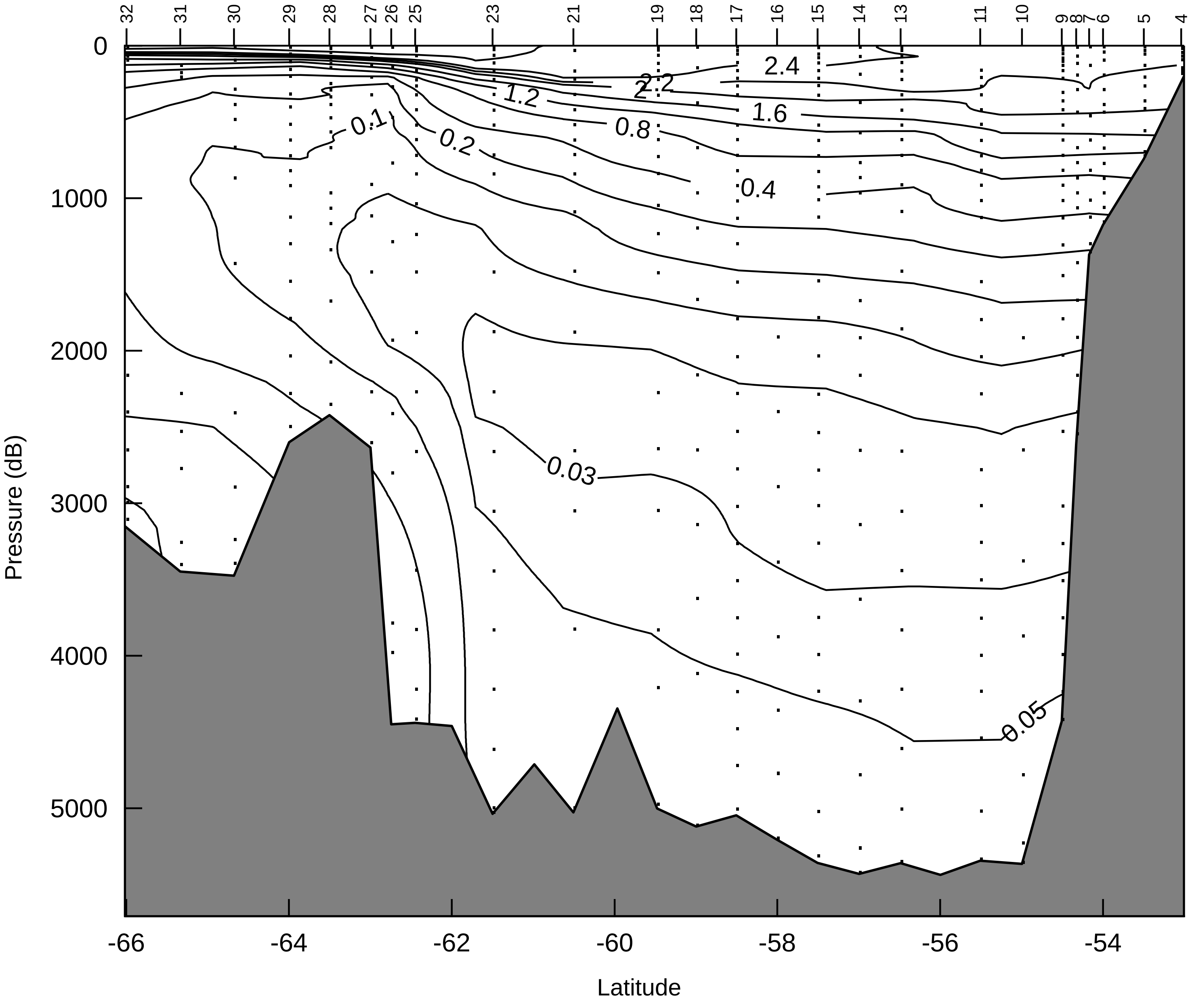

Figure 10a: CFC-12 (pmol/kg)Section along P14S (Preliminary)

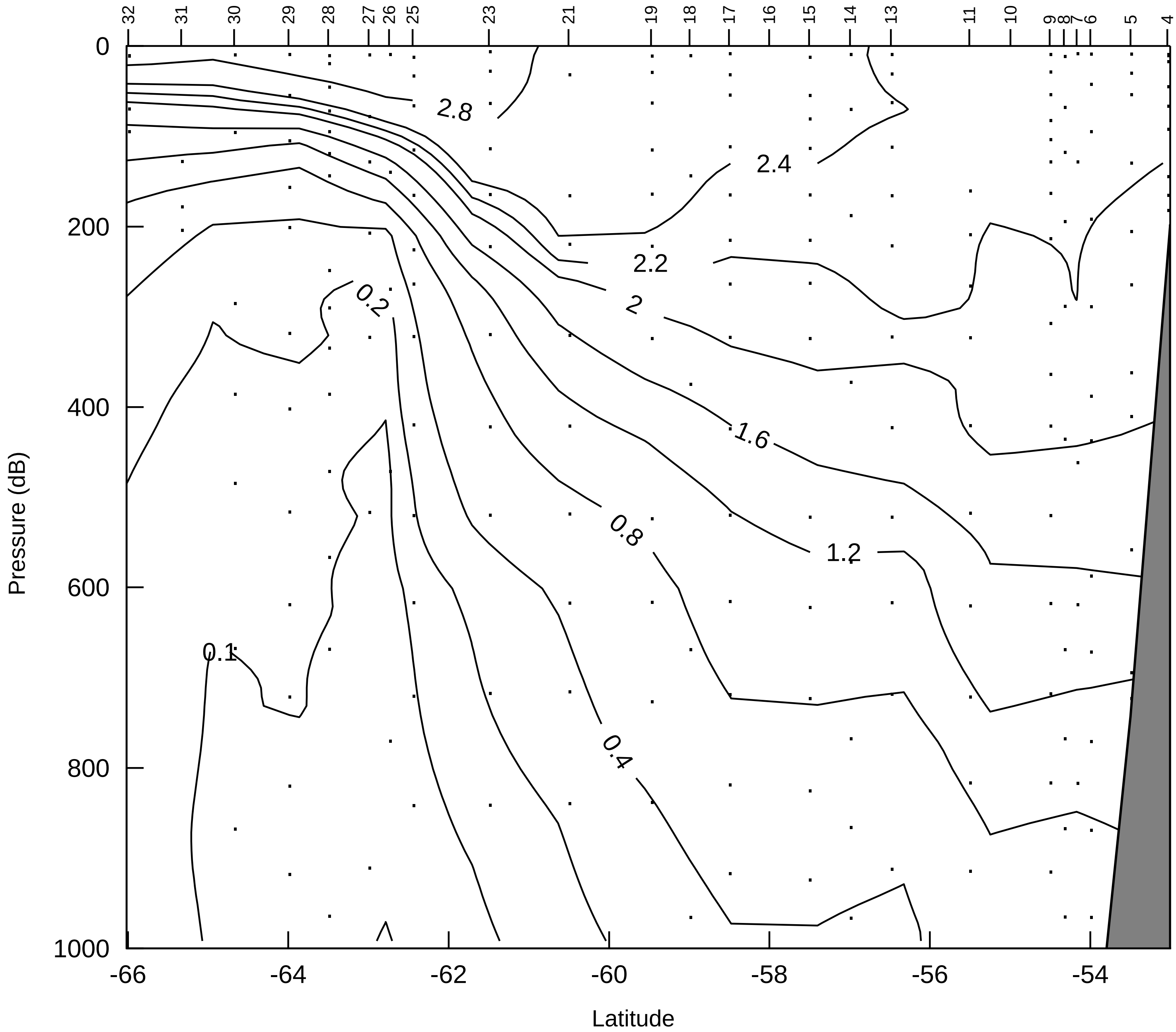

Figure 10b: CFC-12 (pmol/kg) Section along P14S (Preliminary)

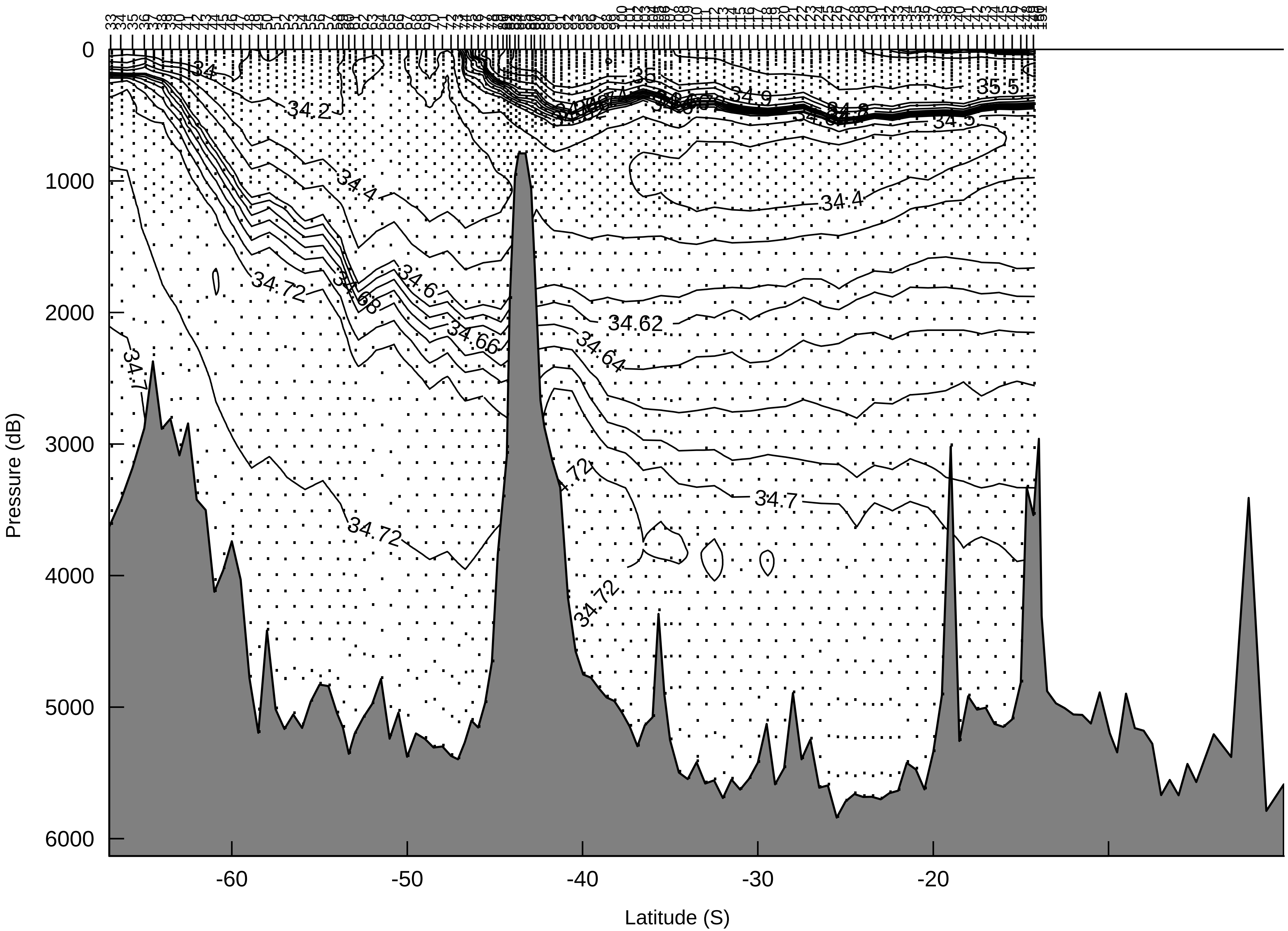

Figure 11a: Salinity Section along P15S (Preliminary)

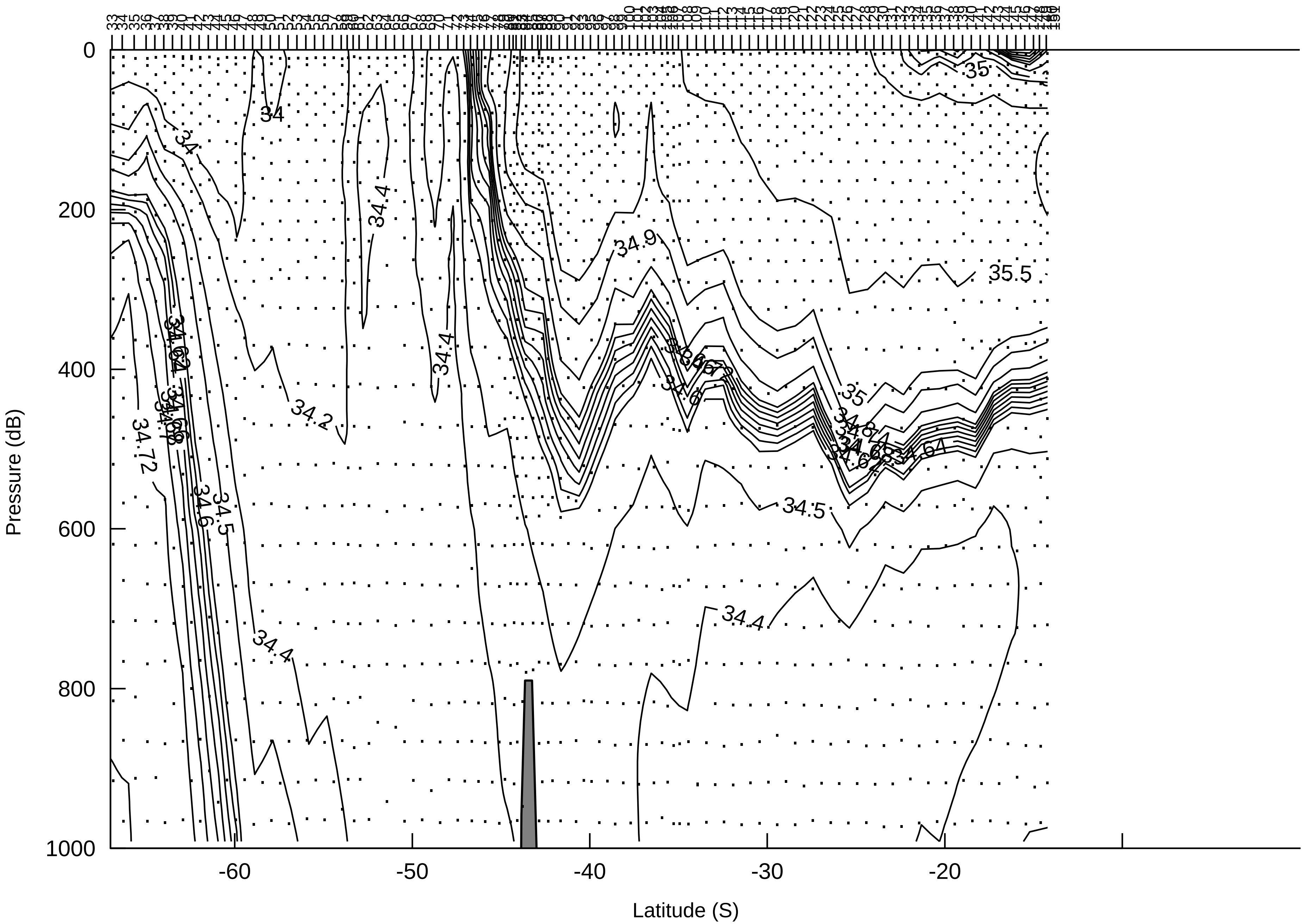

Figure 11b: Salinity Section along P15S (Preliminary)

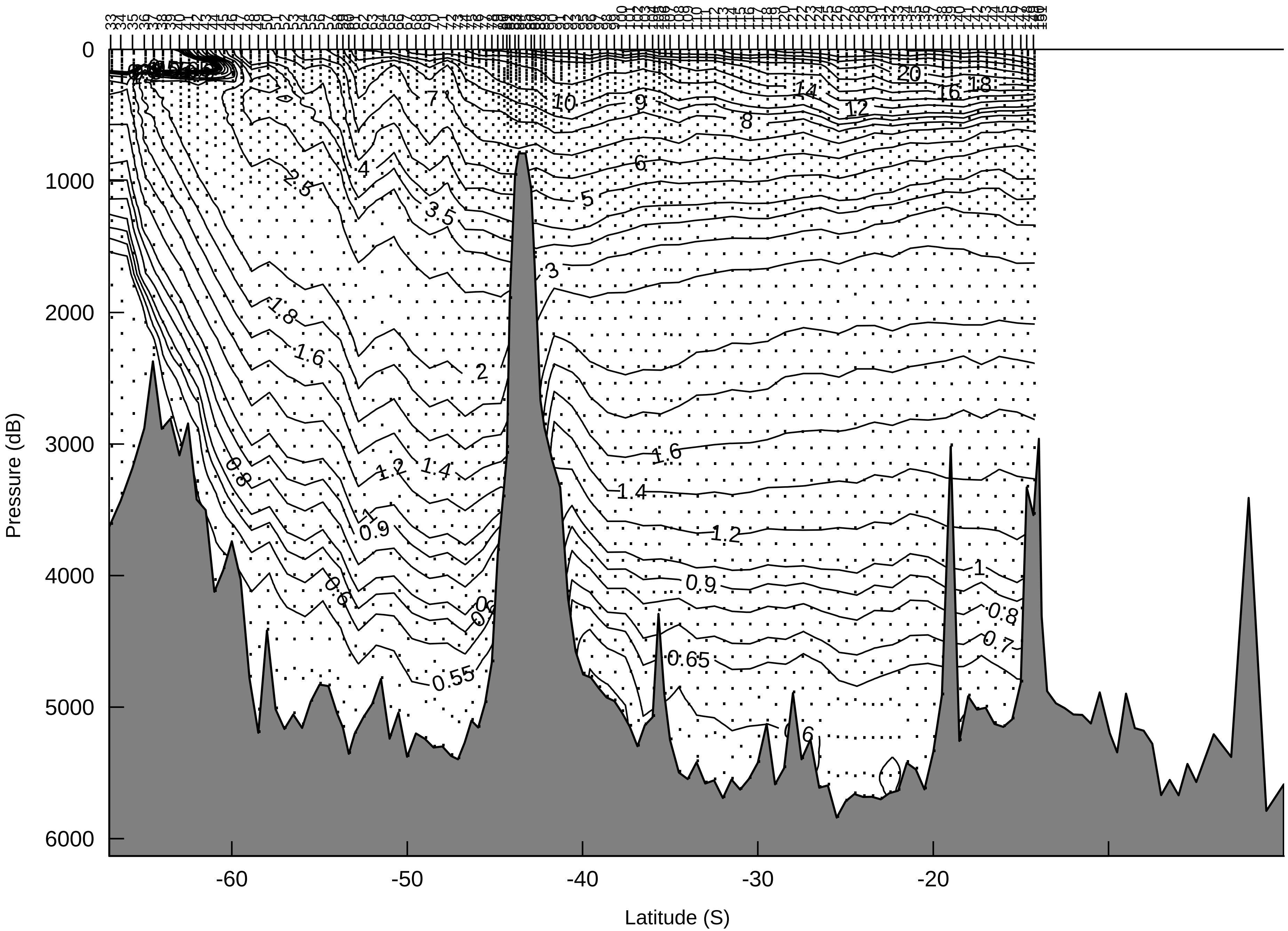

Figure 12a: Potential Temperature along P15S (Preliminary)

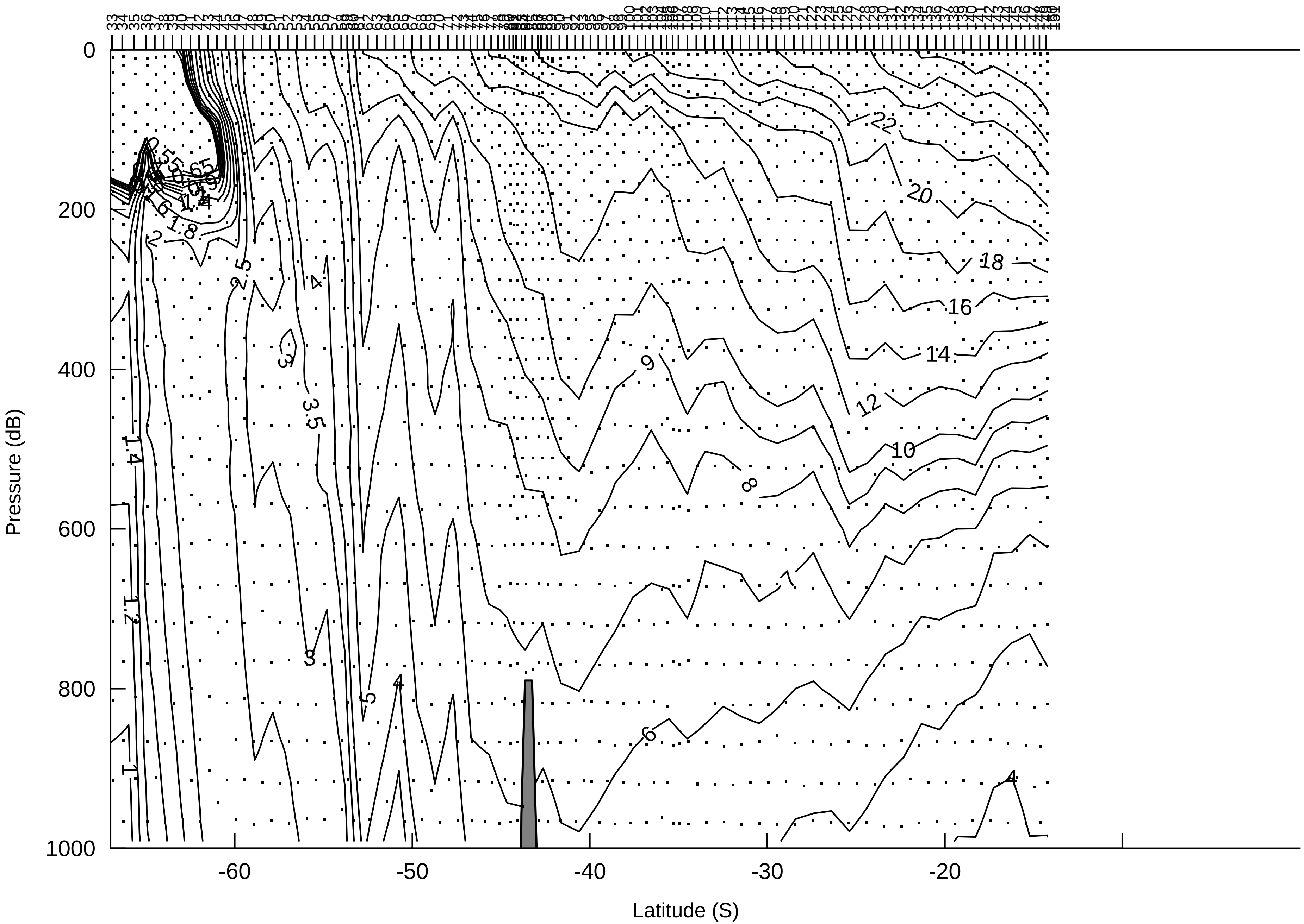

Figure 12b: Potential Temperature along P15S (Preliminary)

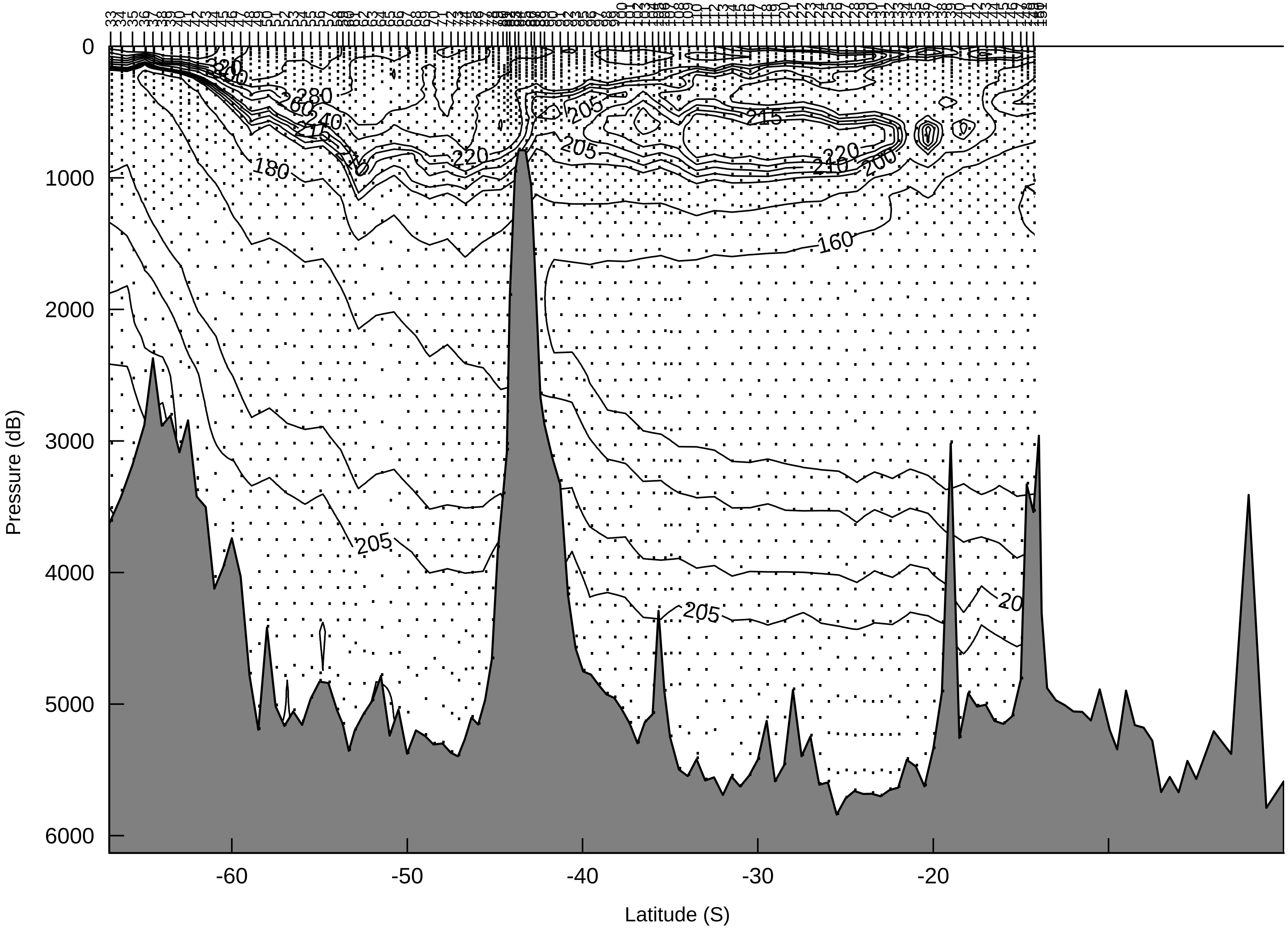

Figure 13a: Oxygen (µmol/kg) Section along P15S (Preliminary)

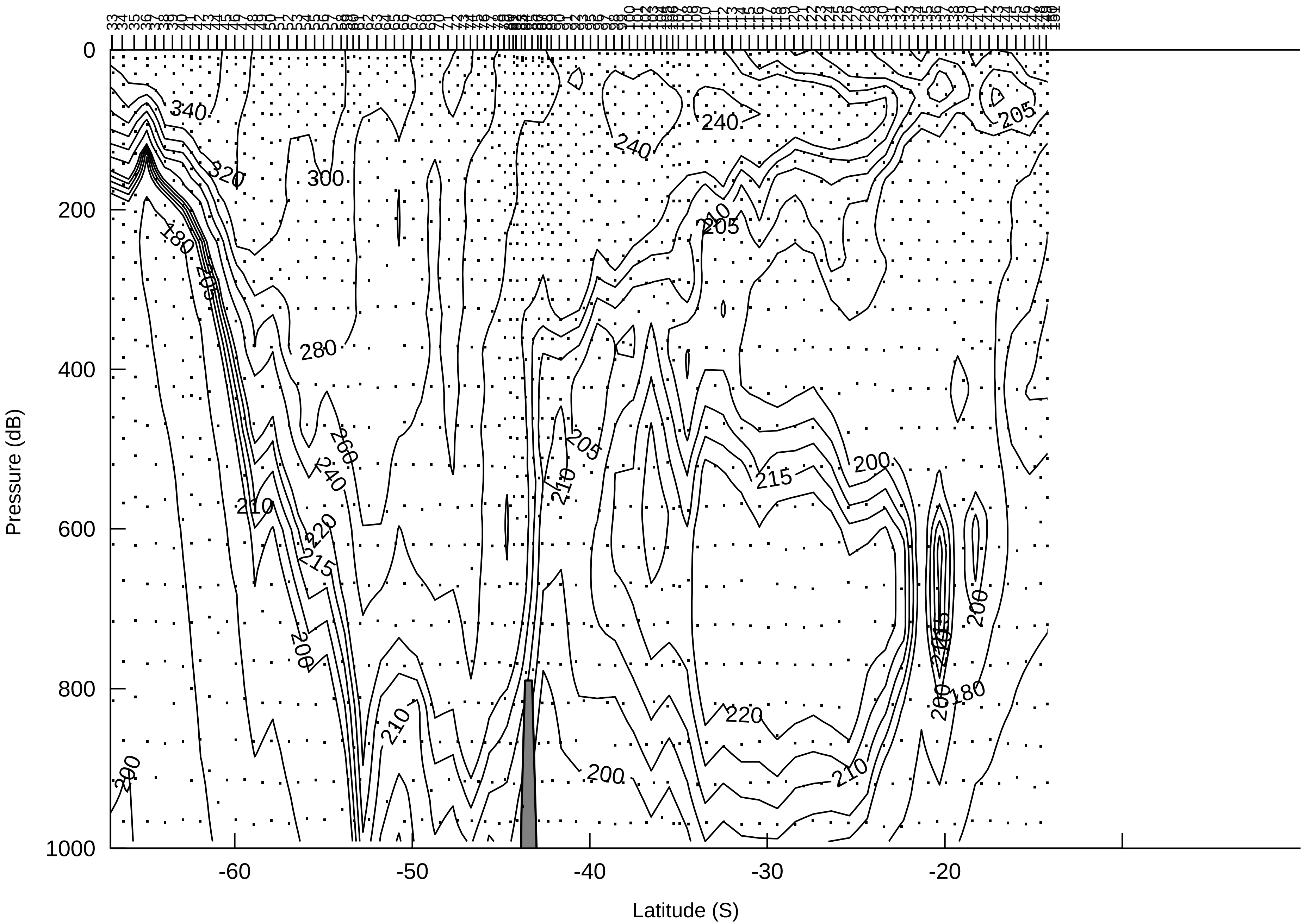

Figure 13b: Oxygen (µmol/kg) Section along P15S (Preliminary)

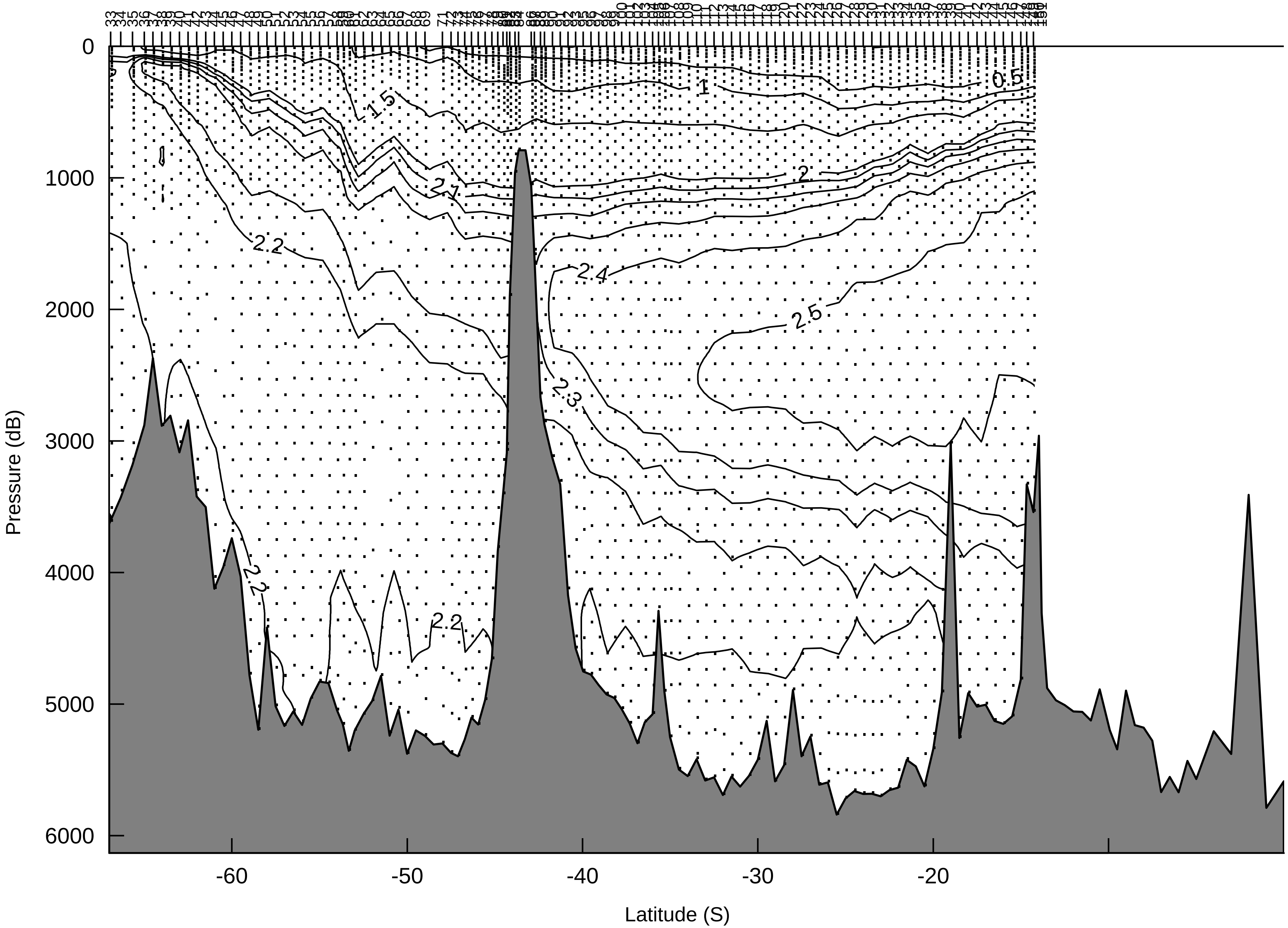

Figure 14a: Phosphate (µmol/kg) Section along P15S (Preliminary)

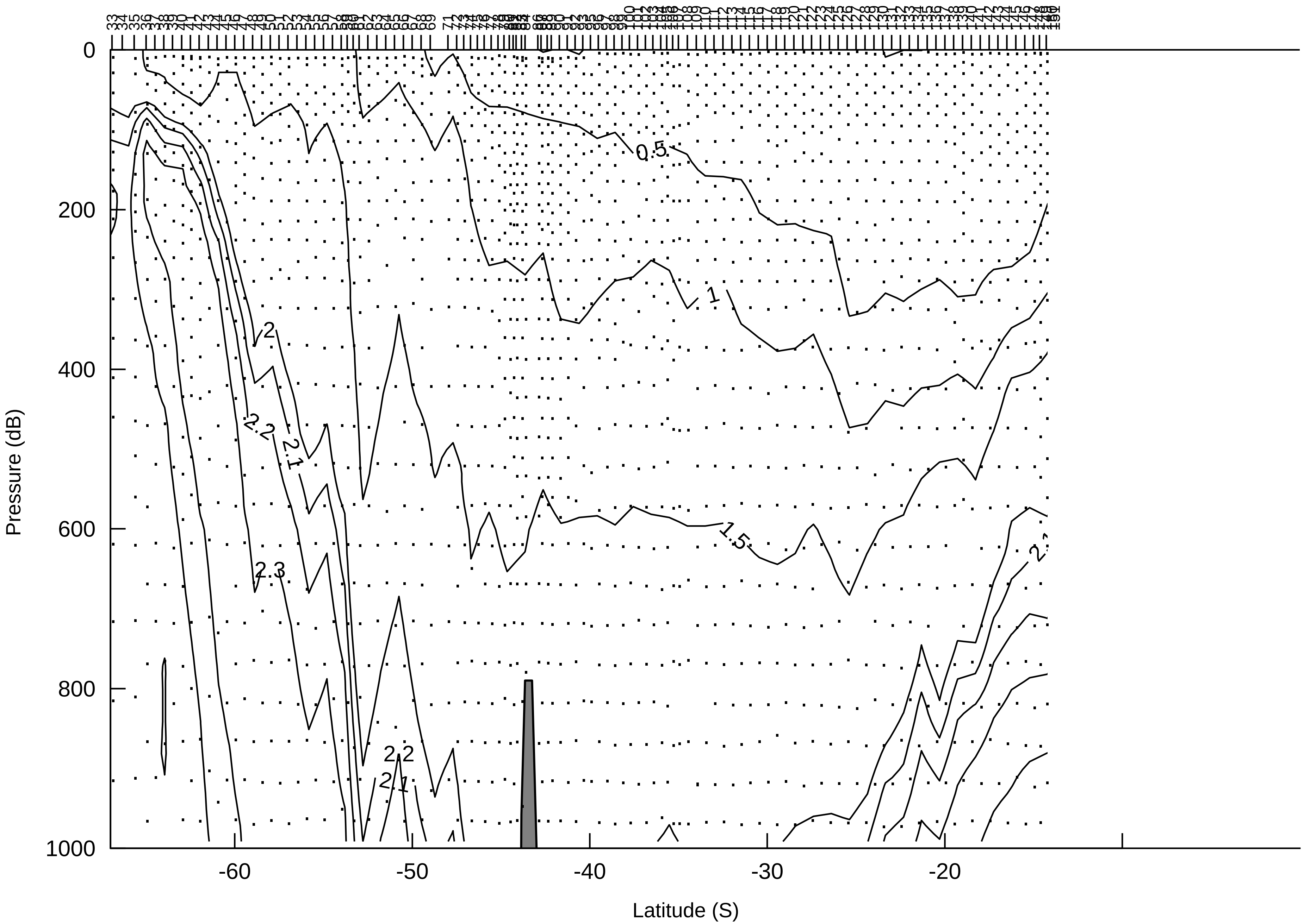

Figure 14b: Phosphate (µmol/kg) Section along P15S (Preliminary)

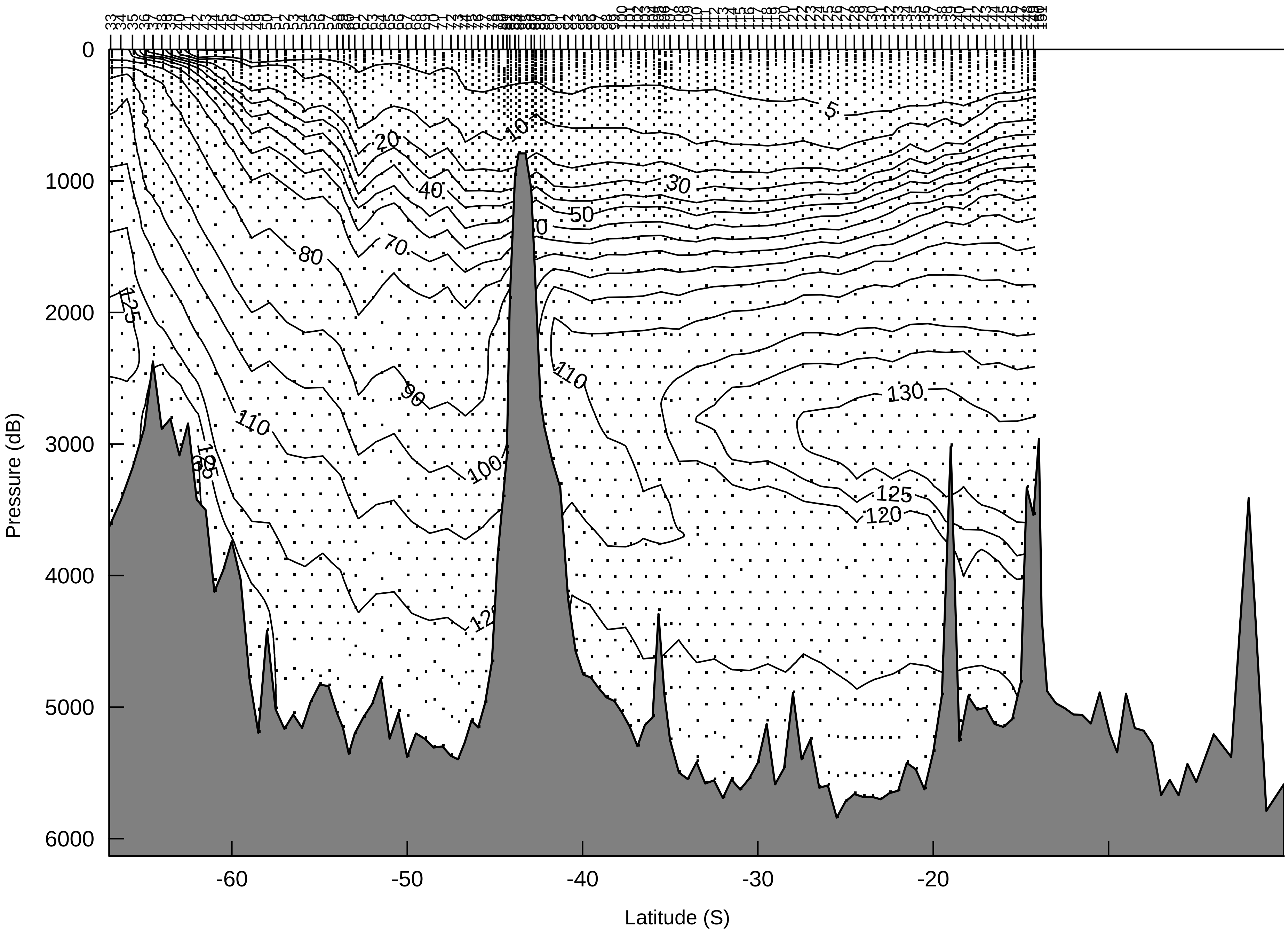

Figure 15a: Silicate (µmol/kg) Section along P15S (Preliminary)

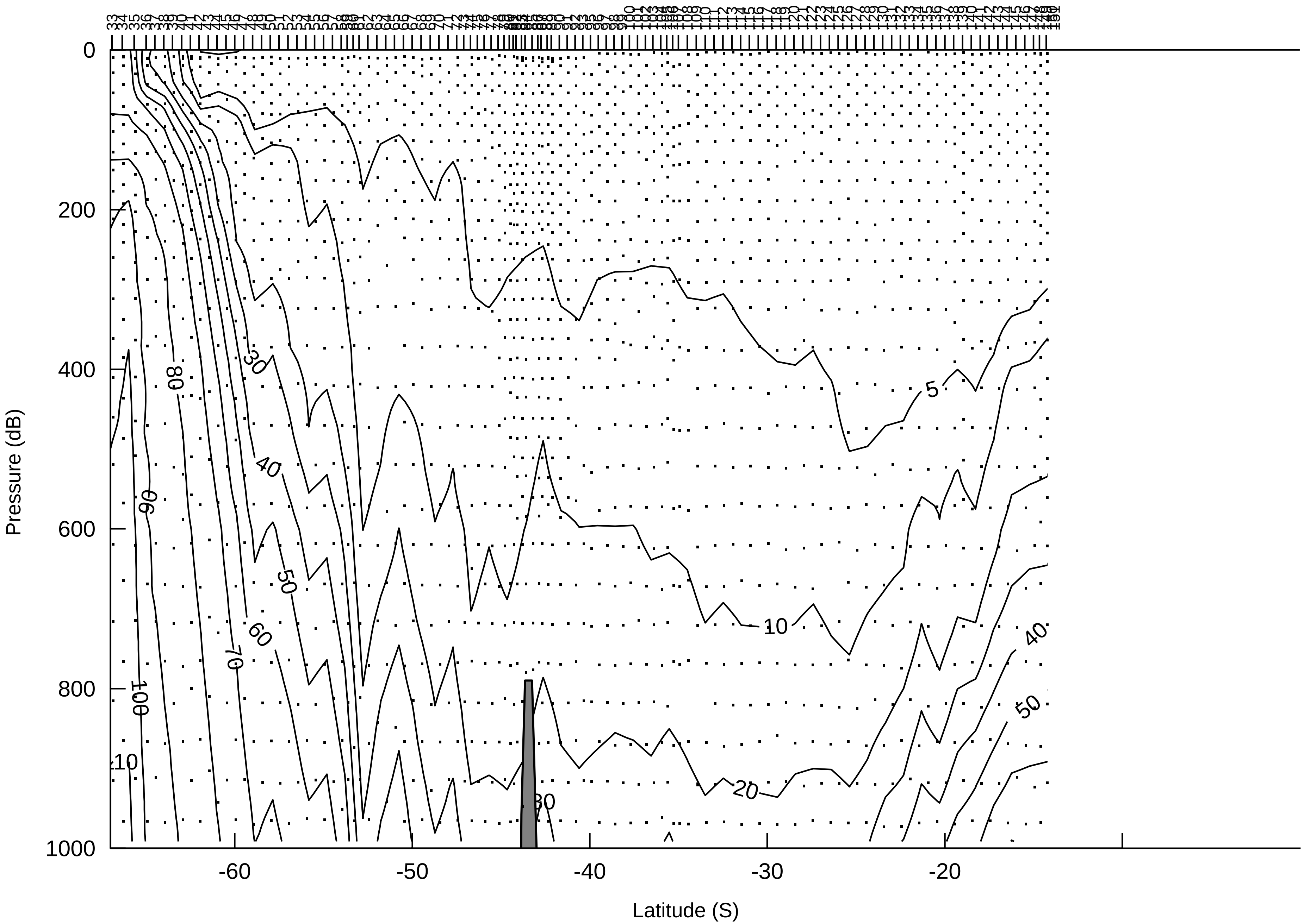

Figure 15b: Silicate (µmol/kg) Section along P15S (Preliminary)

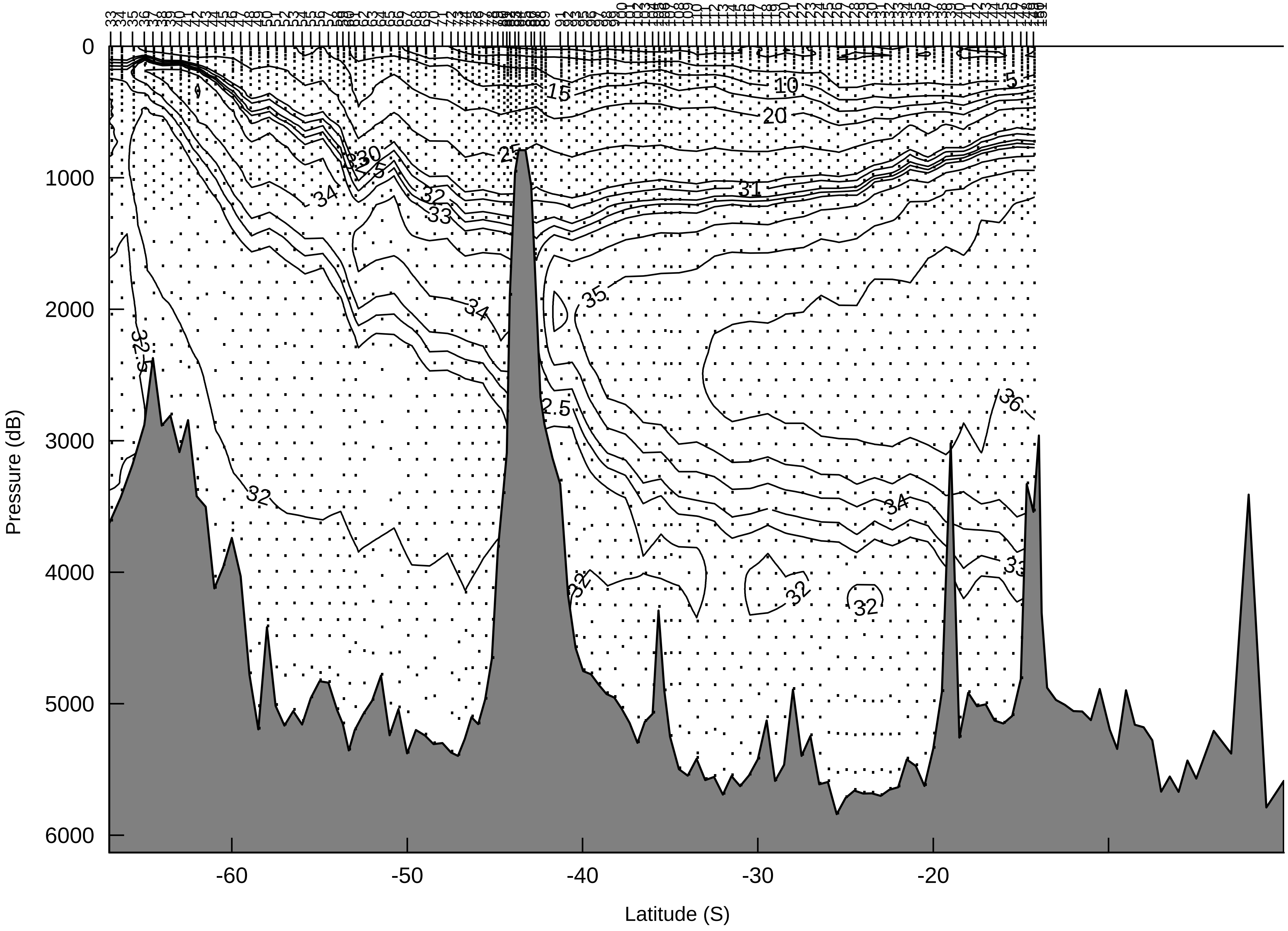

Figure 16a: Nitrate (µmol/kg) Section along P15S (Preliminary)

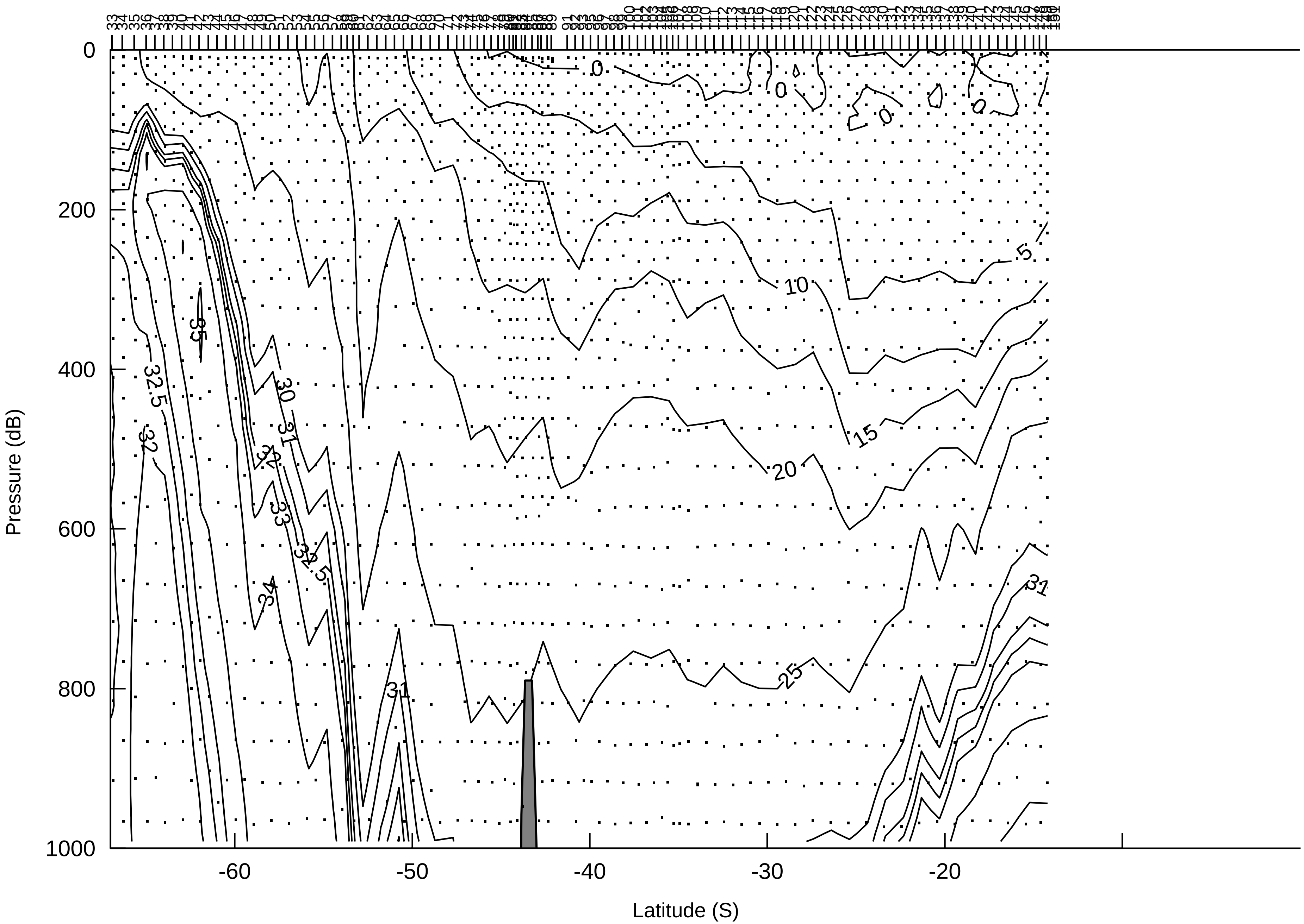

Figure 16b: Nitrate (µmol/kg) Section along P15S (Preliminary)

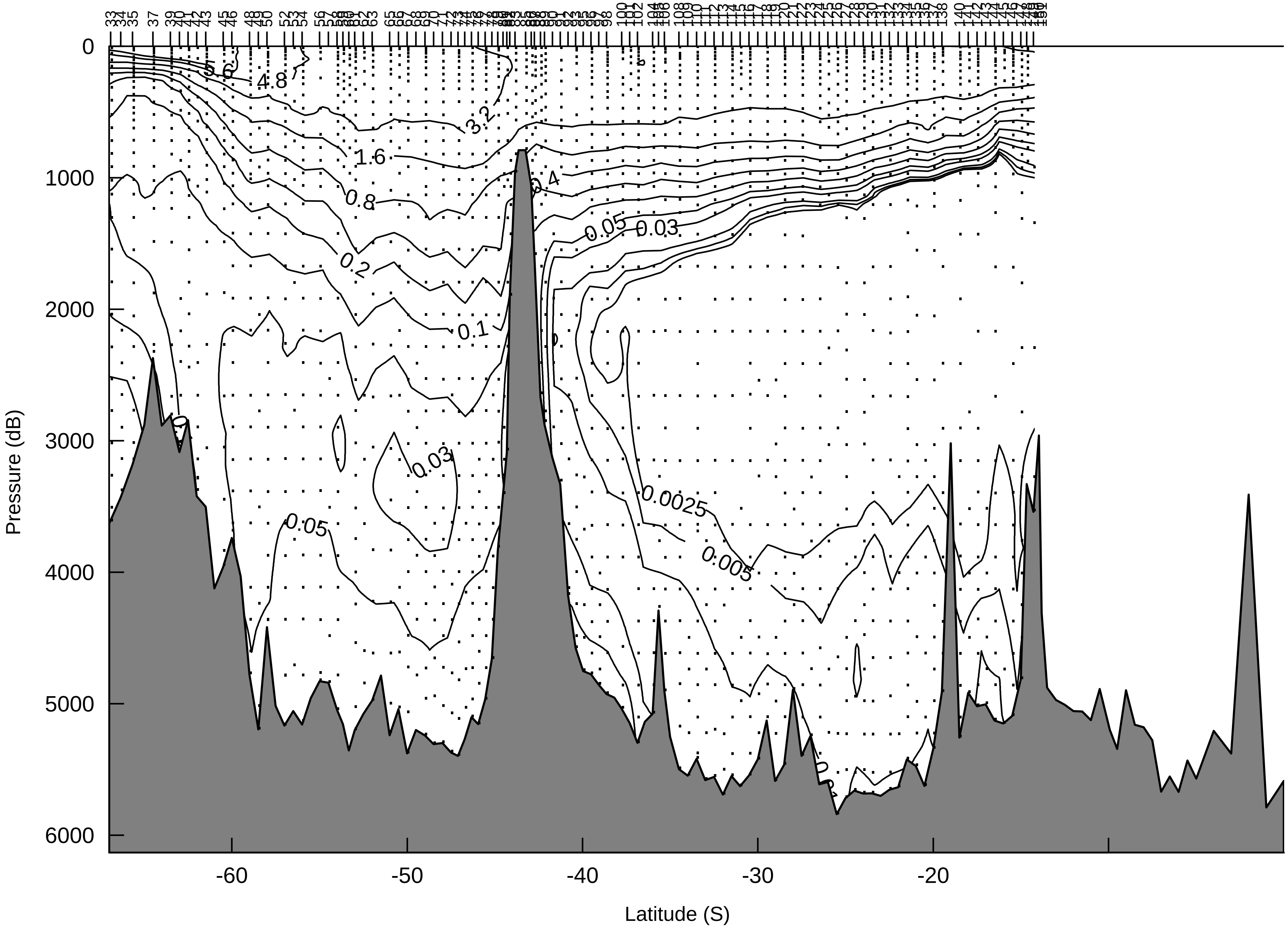

Figure 17a: CFC-11 (pmol/kg) Section along P15S (Preliminary)

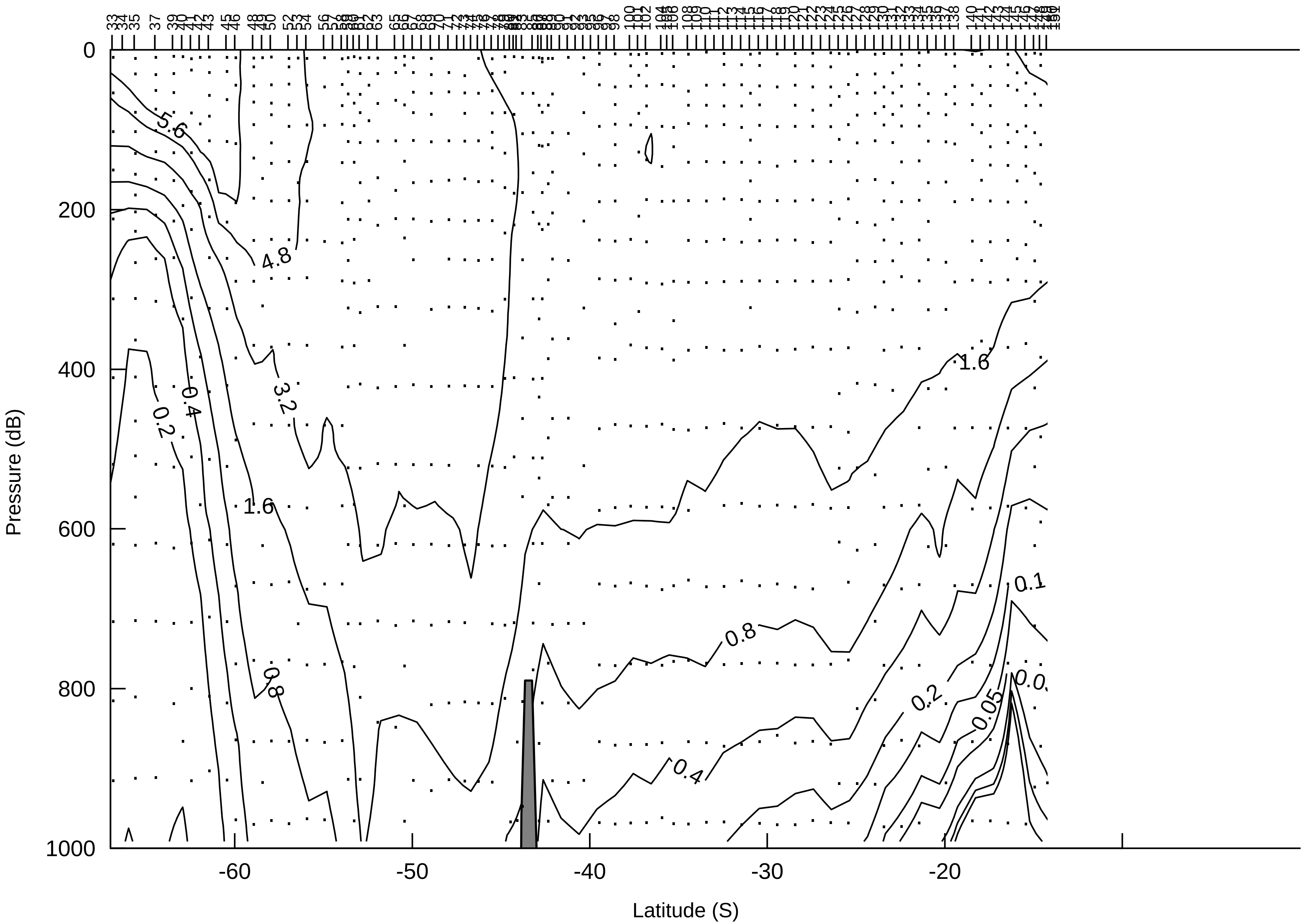

Figure 17b: CFC-11 (pmol/kg) Section along P15S (Preliminary)

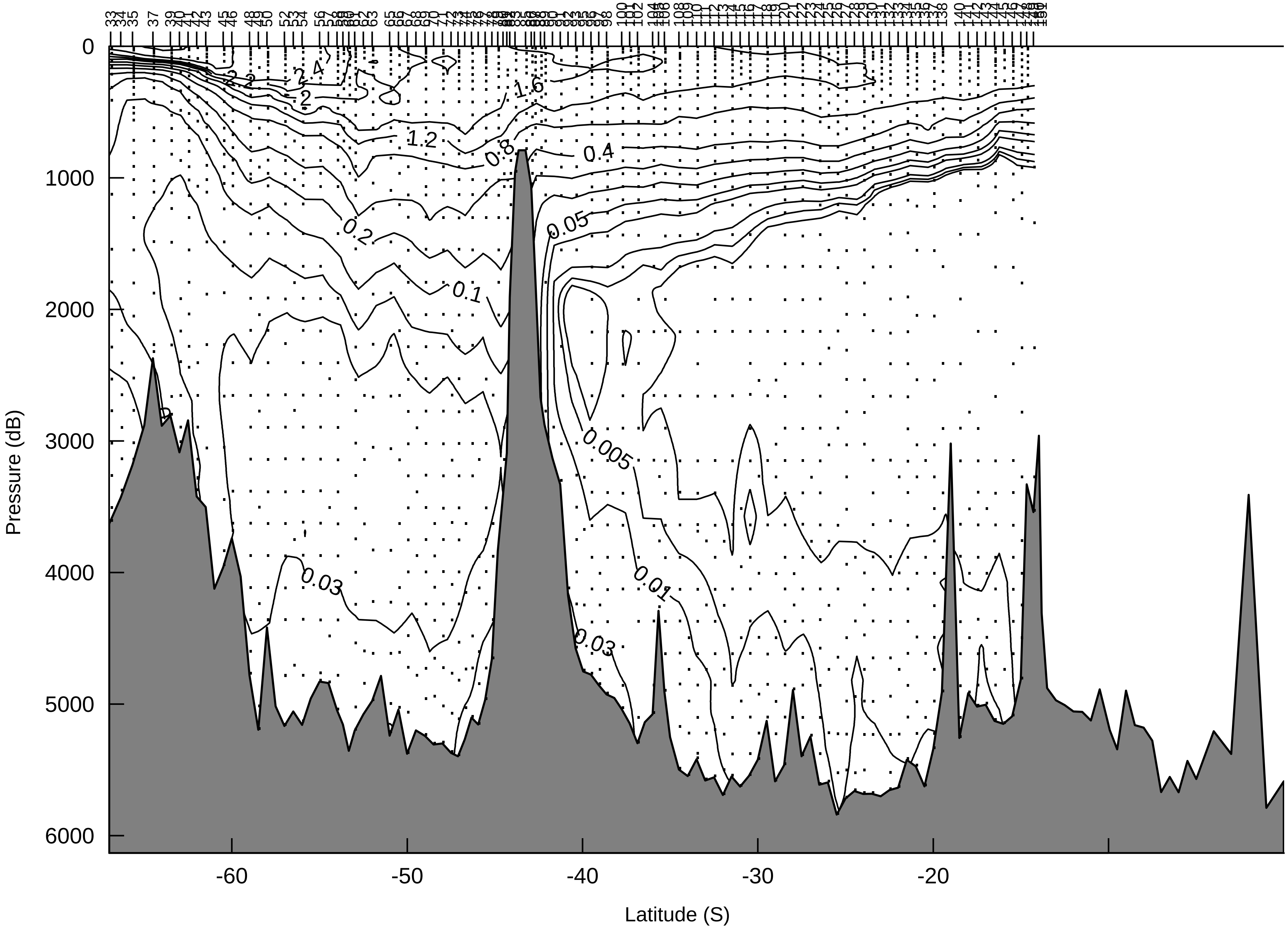

Figure 18a: CFC-12 (pmol/kg) Section along P15S (Preliminary)

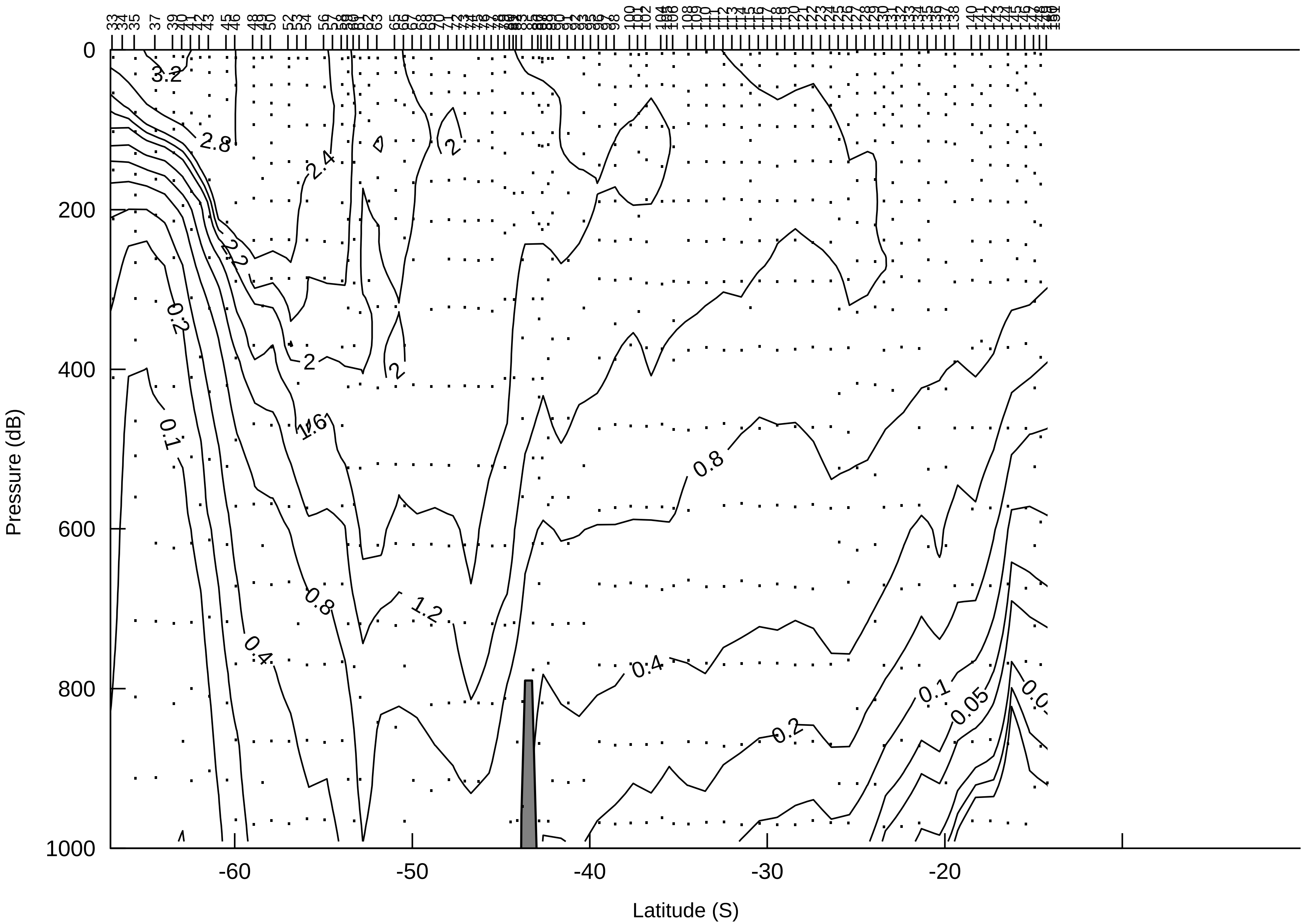

Figure 18b: CFC-12 (pmol/kg) Section along P15S (Preliminary)

B. Hydrographic Measurement Techniques and Calibrations

B.1. Oxygen Measurement Techniques

(Kirk Hargreaves 15 May 1996)

B.1.1. Overview

Oxygen samples were drawn from every bottle for every station (except for some test casts and severely leaking bottles). A total of 5683 samples plus 516 duplicates were analyzed. Four people drew oxygen samples and three people ran analyses. The estimated accuracy, relative to the standards, is 0.1% (potentially 0.05%) plus an estimated precision of 0.2 µmol/kg. Note that precision is sampler dependent and was as good as 0.15 µmol/kg for some samplers. Also, discounting the 12 duplicates (2.5% of total) with more than three sigma error, the total precision is 0.15 µmol/kg. Individual sampler variation is from 0.14 to 0.19 µmol/kg.

Water temperature was not measured at the time of sampling. Previous measurements have shown that even in the tropics, bottom water warms only a few °C before being sampled. For a rise in temperature from 0°C to 4°C, the change in the density of the water is 0.03%. Conversion to µmol/kg is calculated with potential density.

Samples were titrated using Culberson's (Culberson, 1992) modifications to Carpenter's whole bottle technique (Carpenter, 1969). An auto-titrator based on a design by Gernot Friederich (Friederich, 1991) and using a modified version of Friederich's software was used to titrate the samples. The titrator consists of a Kloehn 50100 Syringe Drive with a 5 ml syringe, a custom- built photometer with two color channels, LM35 temperature sensors, an eight channel A/D board, and a computer. Post- processing software was used to add in temperature corrections and to analyze data.

B.1.2 Sampling and Pickling

Oxygen was sampled immediately after CFCs. Samples were drawn in calibrated 125 ml nominal volume iodine determination flasks (Corning 5400-125). The sampling tube was inserted into the flask, allowed to flow freely and squeezed and tapped to remove bubbles, and then inverted. The tube was pinched to reduce flow and allow water in the flask to drain. A water sheet was formed on the inside of the flask, the sampling tube pinched to reduce flow, the flask drained, and then put right-side up. The sampling tube was slowly released to prevent turbulent flow and the flask allowed to fill. For best results, the sampling tube was kept pinched to keep the flow smooth throughout sampling. By counting, the fill time was measured and used to ensure at least two volumes overflow.

Reagents were introduced shortly after sampling using Brinkmann 1.0 ml Fixed Volume Dispensette repipets. The tips of the repipets were lengthened using clear polyolefin shrink tubing. The $MnCl_2$ was added at the midpoint of the flask, and NaOH/NaI just below the neck. Repipets were filled before inserting into the water. If necessary, a little was dispensed to ensure the tubes were full.

Flasks were capped at this point and shaken while pushing on the stopper until the reagents were well mixed. The flask was inverted and checked for bubbles. Deionized water was added to the collar of the flask and the flask stowed. At least 20 minutes after sampling was finished, flasks were reshaken and deionized water added to the collars again.

B.1.3 Analysis

Samples were analyzed no earlier than 20 minutes and no later than 8 hours after remixing. Liquid from the flask collar was aspirated with a transfer pipette and the stopper removed. ~1ml of 10N sulfuric acid and a rinsed, pivotless stir bar were added (pivotless stir bars spin most easily). The flask was inserted into a water bath in the photometer and titrated with 0.05 N sodium thiosulfate. (The water path minimizes refractive effects). After titration, the sample was poured out and the flask rinsed with hot tap water. The typical sample-to-sample time was 1.5 to 2 minutes.

B.1.4 Standardization

Titrant was standardized daily with ~0.01N (actually 0.01 eq/kg) potassium iodate solution. The standard deviation of standardization is 0.05%, though one batch of thiosulfate solution showed a variation of 0.2%. Standards were mixed before the cruise and stored in upside down air tight Boston round bottles. All standards inter-compared before the cruise to better than 0.02%.

Standards were prepared by weight from two ~0.1 eq/kg stock solutions. The stock solutions were made from oven dried and vacuum desiccated KIO3 from two different manufacturers (Mallinckrodt Lot #1094-KHSR and Fisher Lot #951151). In addition, all standards were compared to a volumetrically prepared standard from Baker (pre-weighed KIO3 obtained from Oregon State University. Lot number unknown). Mixing standards by weight is both faster and more accurate than mixing standards volumetrically.

Standard was dispensed using a spare Kloehn 50100 with a calibrated 25 ml buret or an Eppendorf Maxipettor with calibrated tip. Unfortunately, the Eppendorf Maxipettor has a large (0.02%/C) temperature dependence that needs to be taken into account. The measured precision of the dispensed standards is 0.6 uL and 2 uL for the Kloehn and Eppendorf, respectively.

The temperature of the standard was measured directly with a calibrated thin film Pt-RTD (Sensycon GW2107-01) and thermometer (Cole-Parmer H-08497-00). Standard concentration was converted to normality by dividing by then density of pure water at temperature plus 0.03% (mass fraction of the potassium iodate).

B.1.5 Post-processing

Post-processing software written in Perl (Wall, 1991) and using algorithms from "Numerical Recipes in C" (Press, 1988) was used to add in temperature corrections and update standardization. Perl code was also used to generate the correct WOCE flags, average duplicate data, and generate the final output. Lotus 1-2-3 was used to plot curves, compare bottle data to oxygen sensor data, and analyze duplicates.

B.1.6 Reagents

Reagents were gravimetrically prepared before the cruise. 600 g MnCl2 were added to 692.92 g water, and 320 g NaOH and 600 g NaI were added to 753.68 g water. At room temperature, these give molar concentrations equal to the WOCE specifications, but are much faster to mix. Reagents were stored in glass or HDPE bottles.

Oxygen References

Carpenter, J.H., "The Chesapeake Bay Institute Technique for the Winkler Dissolved Oxygen Method", Limnology and Oceanography, vol. 10, pp. 141-143.

Culberson, C.H., "Dissolved Oxygen", WHP Operations and Methods, WHP Office Report WHPO 91-1, July 1992.

Friederich, G.E., Codispoti, L.A., and Sakamoto, C.M., "An Easy- to-Construct Automated Winkler Titration System", MBARI Technical Report 91-6, August 1991.

Press, W.H., Flannery, B.P., Teukolsky, S.A., and Vetterling, W.T., "Numerical Recipies in C", Cambridge University Press, Cambridge, 1988.

Wall, L., and Schwartz, Randal L., "Programming Perl", O'Reilly & Associates, USA, 1991.

Appendix 1: Replicate Oxygen Measurements

These are the standard deviations of the oxygen data duplicates. The averaged data are in the oxygen data file and flagged with a '6'.

Sta	Smp	StdDev	Sta	Smp	StdDev	Sta	Smp	StdDev	Sta	Smp	StdDev
5	104	0.00	34	119	0.02	55	113	0.06	72	103	0.16
6	104	0.15	34	125	0.02	56	106	0.09	72	113	0.06
6	107	0.16	35	104	0.31	56	108	0.16	72	119	0.02
10	204	0.01	35	107	0.19	56	110	0.16	72	127	0.06
10	208	0.17	35	110	0.36	57	107	0.11	73	110	0.13
11	105	0.11	40	108	0.21	57	113	0.02	73	118	0.07
11	110	0.00	40	119	0.18	57	119	0.13	73	126	0.12
11	115	0.06	41	109	0.04	57	125	0.14	74	205	0.39
11	120	0.47	41	115	0.13	58	213	0.10	74	211	0.24
14	112	0.16	41	121	0.79	58	227	0.39	74	216	0.06
14	120	0.27	41	127	0.01	58	231	0.01	74	220	0.20
14	128	0.14	42	107	0.79	59	106	0.32	75	107	0.38
15	207	0.08	42	113	0.19	59	109	0.33	75	115	0.00
15	214	0.19	42	119	0.22	60	104	0.31	75	123	0.41
15	221	0.74	42	125	0.23	60	106	0.78	75	131	0.07
15	229	0.35	46	103	0.17	60	109	0.07	76	213	0.04
16	104	0.64	46	109	0.02	61	105	0.05	76	219	0.35
16	108	0.75	46	115	0.53	61	109	0.19	76	225	0.34
17	104	0.08	46	121	0.19	61	115	0.12	76	231	0.08
17	108	0.05	47	213	0.09	61	119	0.05	77	106	0.01
17	122	0.01	47	217	0.06	62	217	0.05	77	110	0.08
18	105	0.01	47	221	0.00	62	219	0.02	77	112	0.05
18	111	0.04	47	225	0.01	62	225	0.09	77	115	0.08
18	117	0.04	48	104	0.44	62	231	0.07	78	104	0.10
18	123	0.84	48	108	0.34	65	121	0.40	78	107	0.05
28	111	0.05	49	113	0.01	65	123	0.05	78	111	0.01
28	118	0.38	49	117	0.26	66	110	0.08	78	115	0.05
29	203	0.08	50	105	0.16	66	117	0.30	79	111	0.04
29	206	0.08	50	115	0.05	66	122	0.03	79	117	0.03
29	210	0.31	50	121	0.15	66	128	0.06	79	123	0.09
29	214	0.63	50	129	0.03	67	207	0.15	79	129	0.14
30	105	0.10	51	108	0.02	67	209	0.21	80	215	0.04
30	107	0.18	51	114	0.09	67	213	0.24	80	221	0.05
30	117	0.21	51	120	0.03	68	107	0.00	80	227	0.56
30	127	0.12	51	126	0.14	68	115	0.07	81	105	0.06
31	207	0.03	52	105	0.08	68	123	0.20	81	108	0.09
31	215	0.00	52	108	0.11	68	131	0.06	81	113	0.06
31	223	0.24	52	112	0.43	69	208	0.06	82	104	0.15
31	227	0.09	53	105	0.21	69	213	0.12	82	107	0.15
32	104	0.20	53	111	0.04	69	221	0.03	82	110	0.07
32	107	0.20	53	117	0.03	69	229	0.01	88	101	0.00
32	114	0.02	53	121	0.00	70	106	0.35	88	104	0.11
33	105	0.30	54	103	0.09	70	109	0.01	88	106	0.07
33	111	0.91	54	109	0.13	70	111	0.08	89	201	0.14
33	117	0.05	54	115	0.13	71	105	0.22	89	204	0.00
33	123	0.04	54	121	0.05	71	113	0.06	89	208	0.11
34	107	0.10	55	107	0.11	71	119	0.03	90	101	0.07
34	113	0.14	55	110	0.16	71	123	0.08	90	104	0.04

Sta	Smp	StdDev	Sta	Smp	StdDev	Sta	Smp	StdDev	Sta	Smp	StdDev
90	108	0.17	105	232	0.13	121	223	0.08	135	229	0.01
91	107	0.03	106	105	0.04	121	231	0.63	136	101	0.11
91	115	0.16	106	109	0.03	122	101	0.02	136	107	0.10
91	121	0.05	106	121	0.28	122	112	0.01	136	113	0.08
91	127	0.06	106	129	0.09	122	124	0.16	136	119	0.01
92	209	0.12	107	101	0.20	122	136	0.02	137	103	0.04
92	217	0.03	107	112	0.17	123	103	0.03	137	109	0.13
92	225	0.03	107	124	0.09	123	113	0.05	137	115	0.06
92	234	0.07	108	107	0.05	123	123	0.19	137	123	0.14
93	101	0.36	108	117	0.00	123	135	0.08	138	105	0.24
93	105	0.36	108	127	0.01	124	102	0.13	138	111	0.01
93	108	0.12	108	135	0.15	124	112	0.06	138	119	0.09
93	113	0.12	109	105	0.04	124	122	0.65	138	127	0.06
94	105	0.01	109	121	0.19	124	132	0.21	140	104	0.22
94	111	0.24	109	129	0.12	125	301	0.01	140	111	0.08
94	117	0.03	110	212	0.63	125	312	0.13	140	121	0.01
94	123	0.24	110	215	0.03	125	325	0.05	140	131	0.06
95	101	0.17	110	219	0.15	126	101	0.03	141	101	0.08
95	112	0.59	110	227	0.01	126	111	0.06	141	113	0.11
95	124	0.14	111	107	0.07	126	121	0.12	141	125	0.02
96	107	0.03	111	109	0.01	126	131	0.07	141	135	0.12
96	123	0.05	111	115	0.03	127	205	0.01	142	105	0.21
97	209	0.18	111	123	0.10	127	215	0.00	142	111	0.01
97	215	0.00	112	105	0.03	127	225	0.64	142	119	0.02
97	221	0.27	112	113	0.06	127	233	0.25	142	129	0.11
97	227	0.06	112	121	0.15	128	205	0.11	143	105	0.02
98	107	0.01	112	129	0.07	128	211	0.14	143	111	0.12
98	113	0.05	114	112	0.10	128	221	0.21	143	121	0.27
98	122	0.11	114	123	0.05	128	229	0.25	143	129	0.07
98	130	0.05	114	134	0.04	129	102	0.07	144	104	0.24
99	101	0.03	115	107	0.11	129	115	0.05	144	110	0.11
99	112	0.19	115	115	0.04	129	122	0.18	144	117	0.02
99	124	0.01	115	123	0.18	129	131	0.06	144	125	0.10
99	136	0.09	115	131	0.25	130	101	0.49	145	101	0.06
100	107	0.12	116	205	0.03	130	109	0.12	145	107	0.01
100	113	0.08	116	213	0.09	130	117	0.05	145	113	0.17
100	119	0.07	116	221	0.17	130	125	0.05	145	119	0.04
100	125	0.25	116	229	0.06	131	105	0.08	146	103	0.14
101	204	0.52	117	103	0.18	131	111	0.05	146	111	0.28
101	211	0.02	117	109	0.05	131	119	0.01	146	119	0.14
101	219	0.12	117	125	0.10	131	127	0.07	146	128	0.09
101	231	0.06	117	135	0.12	132	101	0.06	147	101	0.26
102	105	0.10	118	101	0.13	132	113	0.14	147	112	0.21
102	115	0.11	118	112	0.04	132	124	0.03	147	125	0.11
102	121	0.03	118	124	0.13	132	136	0.03	147	136	0.08
102	129	0.03	118	136	0.03	133	101	0.01	148	101	0.08
103	101	0.18	119	101	0.10	133	113	0.15	148	111	0.09
103	119	0.21	119	111	0.02	133	125	0.11	148	119	0.02
103	136	0.01	119	121	0.06	133	135	0.07	148	131	0.12
104	105	0.09	119	133	0.00	134	201	0.05	150	201	0.01
104	115	0.03	120	201	0.05	134	211	0.09	150	207	0.00
104	125	0.09	120	211	0.00	134	221	0.11	150	215	0.04
104	135	0.13	120	221	0.04	134	231	0.03	150	225	0.04
105	209	0.07	120	231	0.04	135	203	0.11	151	105	0.01
105	213	0.01	121	205	0.09	135	212	0.06	151	111	0.23
105	223	0.06	121	211	0.21	135	219	0.08	151	118	0.06

Sta	Smp	StdDev	Sta	Smp	StdDev	Sta	Smp	StdDev	Sta	Smp	StdDev
151	125	0.10	157	118	0.09	163	227	0.05	171	121	0.04
152	103	0.14	157	119	0.07	164	101	0.09	171	125	0.02
152	112	0.12	158	104	0.20	164	112	0.07	172	202	0.05
152	124	0.20	158	115	0.04	164	124	0.27	172	217	0.09
152	125	0.25	158	119	0.01	166	209	0.02	172	219	0.09
153	105	0.05	158	125	0.16	166	215	0.17	172	222	0.00
153	113	0.05	159	105	0.06	166	221	0.15	175	203	0.14
153	121	0.03	159	111	0.03	167	205	0.01	175	211	0.15
153	129	0.07	159	119	0.07	167	211	0.22	175	217	0.11
154	101	0.06	159	125	0.17	167	219	0.05	176	101	0.43
154	107	0.06	160	101	0.09	167	225	0.09	176	112	0.03
154	117	0.04	160	112	0.09	168	104	0.30	177	110	0.01
154	131	0.07	160	124	0.05	168	113	0.07	177	113	0.06
155	105	0.07	161	107	0.06	168	123	0.03	178	105	0.01
155	111	0.01	161	115	0.04	168	125	0.04	178	109	0.03
155	119	0.18	161	122	0.00	169	210	0.02	178	115	0.05
155	125	0.01	161	128	0.07	169	220	0.01	179	103	0.06
156	103	0.29	162	204	0.15	169	225	0.06	179	112	0.04
156	109	0.00	162	208	0.09	170	111	0.09	180	108	0.24
156	123	0.01	162	225	0.11	170	119	0.11	180	113	0.12
156	129	0.06	163	205	0.23	170	125	0.08	181	106	0.13
157	109	0.01	163	211	0.13	171	107	0.12	181	108	0.07
157	115	0.06	163	219	0.07	171	115	0.02	182	103	0.02

B.2. Nutrient Measurement Techniques

(Calvin Mordy, NOAA-PMEL)

Nutrient samples were analyzed for dissolved phosphate, silicic acid, nitrate, and nitrite using protocols of Gordon et al., 1993. Samples were collected in 20 ml high-density polyethylene scintillation vials closed with Teflon lined polyethylene caps. All vials and caps were rinsed with 10% HCl prior to each station. Samples were usually analyzed immediately after collection; however, several samples were stored for up to 12 hours at 4-6°C. Samples were analyzed using an Alpkem RFA 300 modified with a custom heating coil and Spectro-100 UV/VIS detectors from Thermo Separation Products. Analytical temperatures were logged twice during every run and ranged from 16 to 25°C. The following analytical methods were employed:

Phosphate was converted to phosphomolybdic acid and reduced with ascorbic acid to form phosphomolybdous acid in a reaction stream heated to 42°C (Bernhardt and Wilhelms, 1967).

Silicic acid was converted to silicomolybdic acid and reduced with stannous chloride to form silicomolybdous acid or molybdenum blue (Armstrong, 1967).

Nitrite was diazotized with sulfanilamide and coupled with NEDA to form a red azo dye.

(NO_3- + NO_2-) was measured by first reducing nitrate to nitrite in a copperized cadmium coil, and then analyzing for nitrite. Nitrate was determined from the difference of (NO_3- + NO_2-) and NO_2- (Armstrong, 1967).

Concentrations were converted to µmol/kg by calculating sample densities using the laboratory temperature during analysis, the bottle or CTD salinity, and the international equation of state (UNESCO, 1981).

Primary standards were prepared by dissolving standard material in deionized water, and working standards were freshly made at each station in low nutrient seawater. Standard material for silicic acid was sodium fluorosilicate which had been referenced against a fused-quartz standard. All analysis were within the linear range of the instrument.

Analytical precision was determined from replicate analysis (2 to 7 measurements) on one or more samples at almost every station. Average standard deviations (µmol/kg) for replicate analysis were 0.008 for phosphate (n = 205), 0.08 for silicic acid (n = 408), 0.05 for nitrate (n = 378) and 0.004 for nitrite (n = 15, for samples > 0.05 µmol/kg).

Nutrients References

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B.3. CFC-11 and CFC-12 Measurement Techniques

(J.Bullister, NOAA-PMEL)

Specially designed 10 liter water sample bottles were used on the cruise to reduce CFC contamination. These bottles have the same outer dimensions as standard 10 liter Niskin bottles, but use a modified end-cap design to minimize the contact of the water sample with the end-cap O-rings after closing. The O-rings used in these water sample bottles were vacuum-baked prior to the first station. Stainless steel springs covered with a nylon powder coat were substituted for the internal elastic tubing standardly used to close Niskin bottles.

Water samples for CFC analysis were usually the first samples collected from the 10 liter bottles. Care was taken to co-ordinate the sampling of CFCs with other samples to minimize the time between the initial opening of each bottle and the completion of sample drawing. In most cases, dissolved oxygen, total CO_2, alkalinity and pH samples were collected within several minutes of the initial opening of each bottle. To minimize contact with air, the CFC samples were drawn directly through the stopcocks of the 10 liter bottles into 100 ml precision glass syringes equipped with 2-way metal stopcocks. The syringes were immersed in a holding tank of clean surface seawater until analyses.

To reduce the possibility of contamination from high levels of CFCs frequently present in the air inside research vessels, the CFC extraction/analysis system and syringe holding tank were housed in a modified 20' laboratory van on the deck of the ship.

For air sampling, a ~100 meter length of 3/8" OD Dekaron tubing was run from the CFC lab van to the bow of the ship. Air was sucked through this line into the CFC van using an Air Cadet pump. The air was compressed in the pump, with the downstream pressure held at about 1.5 atm using a back-pressure regulator. A tee allowed a flow (~100 cc/min) of the compressed air to be directed to the gas sample valves, while the bulk flow of the air (>7 liter/minute) was vented through the back pressure regulator.

Concentrations of CFC-11 and CFC-12 in air samples, seawater and gas standards on the cruise were measured by shipboard electron capture gas chromatography (EC-GC), using techniques similar to those described by Bullister and Weiss (1988). For seawater analyses, a ~30-ml aliquot of seawater from the glass syringe was transferred into the glass sparging chamber. The dissolved CFCs in the seawater sample were extracted by passing a supply of CFC-free purge gas through the sparging chamber for a period of 4 minutes at ~70 cc/min. Water vapor was removed from the purge gas while passing through a short tube of magnesium perchlorate desiccant. The sample gases were concentrated on a cold-trap consisting of a 3-inch section of 1/8-inch stainless steel tubing packed with Porapak N (60-80 mesh) immersed in a bath of isopropanol held at -20°C. After 4 minutes of purging the seawater sample, the sparging chamber was closed and the trap isolated. The cold isopropanol in the bath was forced away from the trap which was heated electrically to 125°C. The sample gases held in the trap were then injected onto a precolumn (12 inches of 1/8-inch O.D. stainless steel tubing packed with 80-100 mesh Porasil C, held at 90°C), for the initial separation of the CFCs and other rapidly eluting gases from more slowly eluting compounds. The CFCs then passed into the main analytical column (10 feet, 1/8-inch stainless steel tubing packed with Porasil C 80-100 mesh, held at 90°C), and then into the EC detector.

The CFC analytical system was calibrated frequently using standard gas of known CFC composition. Gas sample loops of known volume were thoroughly flushed with standard gas and injected into the system. The temperature and pressure was recorded so that the amount of gas injected could be calculated. The procedures used to transfer the standard gas to the trap, precolumn, main chromatographic column and EC detector were similar to those used for analyzing water samples. Two sizes of gas sample loops were present in the analytical system. Multiple injections of these loop volumes could be done to allow the system to be calibrated over a relatively wide range of CFC concentrations. Air samples and system blanks (injections of loops of CFC-free gas) were injected and analyzed in a similar manner. The typical analysis time for seawater, air, standard and blank samples was about 12 minutes.

Concentrations of CFC-11 and CFC-12 in air, seawater samples and gas standards are reported relative to the SIO93 calibration scale (Cunnold, et. al., 1994). CFC concentrations in air and standard gas are reported in units of mole fraction CFC in dry gas, and are typically in the parts-per-trillion (ppt) range. Dissolved CFC concentrations are given in units of picomoles of CFC per kg seawater (pmol/kg). CFC concentrations in air and seawater samples were determined by fitting their chromatographic peak areas to multi-point calibration curves, generated by injecting multiple sample loops of gas from a CFC working standard (PMEL cylinder 33790) into the analytical instrument. The concentrations of CFC-11 and CFC-12 in this working standard were calibrated before and after the cruise versus a primary standard (36743) (Bullister, 1984). No measurable drift in the concentrations of CFC-11 and CFC-12 in the working standard could be detected during this interval. Full range calibration curves were run at intervals of ~ 3 days during the cruise. Single injections of a fixed volume of standard gas at one atmosphere were run much more frequently (at intervals of 1 to 2 hours) to monitor short term changes in detector sensitivity.

Extremely low (<0.01 pmol/kg) CFC concentrations were measured in deep water (2000-3000 meters) from about 30oS to the equator along the P15S section, as expected from CFC measurements made during the earlier occupation of this section in 1990 (Wisegarver et al, 1995), and from other transient tracer studies made in this region of the southwest Pacific. Based on the median of CFC concentration measurements in the deep water of this region, which is believed to be nearly CFC-free, a blank correction of 0.003 pmol/kg for CFC-11 and 0 pmol/kg for CFC-12 have been applied to the data set. For very low concentration water samples, subtraction of the water sample CFC-11 blank from the measured CFC-11 water sample concentration yields a small negative reported value.

On this expedition, we estimate precisions (1 standard deviation) of about 1% or 0.005 pmol/kg (whichever is greater) for dissolved CFC-11 and CFC-12 measurements (see listing of replicate samples given at the end of this report). A number of water samples had clearly anomalous CFC-11 and/or CFC-12 concentrations relative to adjacent samples. These anomalous samples appeared to occur more or less randomly during the cruise, and were not clearly associated with other features in the water column (e.g. elevated oxygen concentrations, salinity or temperature features, etc.). This suggests that the high values were due to individual, isolated low-level CFC contamination events. These samples are included in this report and are give a quality flag of either 3 (questionable measurement) or 4 (bad measurement). A total ~24 analyses of CFC-11 were assigned a flag of 3 and ~33 analyses of CFC-12 were assigned a flag of 3. A total of ~31 analyses of CFC-11 were assigned a flag of 4 and ~178 CFC-12 samples assigned a flag of 4.

A value of -9.0 is used for missing values in the listings.

CFC References

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Appendix 2a: CFC Air Measurements (interpolated to station locations)

STATION NUMBER	Latitude	Longitude	Date	F11 PPT	F12 PPT
1	45 49.5 S	153 05.1 E	6 Jan 96	260.5	519.1
2	48 19.1 S	158 29.9 E	7 Jan 96	260.5	519.1
3	50 05.0 S	162 29.3 E	8 Jan 96	260.5	519.1
4	53 00.1 S	169 59.3 E	9 Jan 96	260.5	519.1
5	53 29.9 S	170 29.7 E	9 Jan 96	260.5	519.1
6	53 59.9 S	171 00.1 E	9 Jan 96	260.5	519.1
7	54 10.2 S	171 10.8 E	9 Jan 96	260.5	519.1
8	54 19.8 S	171 20.2 E	9 Jan 96	260.5	519.1
9	54 30.3 S	171 29.8 E	9 Jan 96	260.4	519.2
10	54 59.7 S	172 00.7 E	10 Jan 96	260.5	519.9
11	55 30.4 S	172 27.0 E	10 Jan 96	260.2	519.5
12	55 59.8 S	173 00.6 E	10 Jan 96	260.2	519.5
13	56 29.2 S	173 30.2 E	11 Jan 96	260.2	519.4
14	56 59.7 S	173 58.6 E	11 Jan 96	260.2	519.4
15	57 30.3 S	173 58.5 E	11 Jan 96	260.2	519.4
16	58 00.2 S	173 59.5 E	12 Jan 96	260.2	519.4
17	58 30.2 S	173 58.2 E	12 Jan 96	260.4	519.7
18	58 59.8 S	174 00.0 E	12 Jan 96	260.4	519.7
19	59 28.7 S	173 59.7 E	12 Jan 96	259.8	519.3
20	59 57.9 S	173 57.9 E	13 Jan 96	259.5	519.1
21	60 30.3 S	173 57.8 E	13 Jan 96	259.4	519.3
22	60 59.1 S	173 58.9 E	14 Jan 96	259.4	519.3
23	61 30.0 S	174 00.2 E	14 Jan 96	259.4	519.3
24	62 00.0 S	173 16.1 E	14 Jan 96	259.4	519.3
25	62 26.9 S	172 35.2 E	14 Jan 96	259.4	519.3
26	62 44.7 S	172 09.0 E	15 Jan 96	259.4	519.3
27	62 60.0 S	171 44.9 E	15 Jan 96	259.4	519.3
28	63 30.1 S	170 59.6 E	15 Jan 96	259.4	519.3
29	63 59.8 S	171 06.6 E	16 Jan 96	259.4	519.3
30	64 40.6 S	170 58.6 E	16 Jan 96	259.4	519.3
31	65 20.2 S	170 60.0 E	16 Jan 96	259.4	519.3
32	66 00.9 S	171 01.6 E	17 Jan 96	259.4	519.3
33	66 59.6 S	170 00.0 W	18 Jan 96	261.4	522.5
34	66 20.3 S	169 60.0 W	18 Jan 96	261.4	522.5
35	65 39.8 S	170 00.3 W	19 Jan 96	261.4	522.5
36	64 59.6 S	170 00.9 W	19 Jan 96	261.4	522.5
37	64 30.1 S	169 59.9 W	19 Jan 96	260.3	523.7
38	63 59.7 S	170 02.0 W	19 Jan 96	260.3	523.7
39	63 30.1 S	170 00.3 W	20 Jan 96	260.3	523.7
40	62 59.7 S	170 01.4 W	20 Jan 96	260.0	522.5
41	62 30.0 S	169 59.8 W	20 Jan 96	259.3	521.5
42	62 00.2 S	169 59.9 W	20 Jan 96	259.3	521.5
43	61 29.5 S	169 60.0 W	21 Jan 96	259.2	523.0
44	61 00.1 S	170 00.3 W	21 Jan 96	259.2	523.0
45	60 29.7 S	169 59.6 W	22 Jan 96	259.0	522.9
46	60 00.3 S	170 00.3 W	22 Jan 96	259.0	522.9
47	59 30.2 S	169 59.9 W	22 Jan 96	259.0	522.9
48	58 59.9 S	170 00.2 W	22 Jan 96	259.8	524.5
49	58 29.6 S	170 00.8 W	23 Jan 96	259.8	524.5

STATION NUMBER	Latitude	Longitude	Date	F11 PPT	F12 PPT
50	57 59.7 S	170 00.8 W	23 Jan 96	259.8	524.5
51	57 30.1 S	170 00.4 W	23 Jan 96	259.8	524.5
52	57 00.2 S	170 00.2 W	24 Jan 96	259.8	524.5
53	56 29.9 S	169 59.8 W	24 Jan 96	259.8	524.5
54	55 60.0 S	170 01.8 W	24 Jan 96	261.8	521.8
55	55 29.9 S	170 00.0 W	24 Jan 96	261.8	521.8
56	54 59.8 S	169 60.0 W	25 Jan 96	261.2	520.6
57	54 29.4 S	170 00.1 W	25 Jan 96	261.2	520.6
58	54 00.1 S	169 59.3 W	25 Jan 96	261.2	520.6
59	53 39.9 S	169 59.4 W	25 Jan 96	261.3	520.1
60	53 19.9 S	169 59.6 W	26 Jan 96	261.3	520.1
61	52 60.0 S	170 00.5 W	26 Jan 96	261.3	520.1
62	52 29.9 S	170 01.8 W	26 Jan 96	261.3	520.1
63	52 00.1 S	170 07.8 W	26 Jan 96	261.3	520.1
64	51 30.0 S	170 00.2 W	27 Jan 96	261.3	520.1
65	51 00.2 S	170 00.4 W	27 Jan 96	261.3	520.1
66	50 29.9 S	169 59.6 W	27 Jan 96	260.2	519.6
67	50 00.4 S	169 59.9 W	28 Jan 96	260.2	519.6
68	49 30.2 S	170 00.9 W	28 Jan 96	260.2	519.6
69	48 59.6 S	169 59.4 W	28 Jan 96	260.3	519.7
70	48 30.0 S	170 00.2 W	28 Jan 96	260.4	520.1
71	47 59.8 S	170 00.3 W	29 Jan 96	260.4	520.1
72	47 30.2 S	169 59.8 W	29 Jan 96	260.4	520.1
73	47 06.5 S	170 27.7 W	29 Jan 96	260.4	520.1
74	46 43.4 S	170 54.7 W	30 Jan 96	260.4	520.1
75	46 20.0 S	171 22.2 W	30 Jan 96	260.4	520.1
76	45 57.0 S	171 49.5 W	30 Jan 96	260.4	520.1
77	45 33.6 S	172 16.7 W	30 Jan 96	260.4	520.1
78	45 10.6 S	172 44.2 W	31 Jan 96	260.7	520.4
79	44 50.1 S	173 08.2 W	31 Jan 96	260.7	520.4
80	44 31.8 S	173 29.4 W	31 Jan 96	261.0	520.5
81	44 19.2 S	173 44.7 W	31 Jan 96	261.0	520.5
82	44 09.4 S	173 56.3 W	1 Feb 96	261.0	520.5
83	43 50.9 S	174 17.7 W	1 Feb 96	261.0	520.5
84	43 38.8 S	174 32.2 W	1 Feb 96	261.0	520.5
85	43 15.2 S	174 59.9 W	1 Feb 96	261.0	520.5
86	42 55.9 S	174 47.2 W	1 Feb 96	261.0	520.5
87	42 44.8 S	174 39.3 W	1 Feb 96	261.0	520.5
88	42 24.1 S	174 24.4 W	1 Feb 96	261.0	520.5
89	42 10.0 S	174 15.0 W	2 Feb 96	261.0	520.5
90	41 42.8 S	173 56.5 W	2 Feb 96	261.0	520.5
91	41 16.0 S	173 38.6 W	2 Feb 96	261.0	520.5
92	40 49.5 S	173 19.5 W	2 Feb 96	261.0	520.5
93	40 23.6 S	173 02.0 W	2 Feb 96	261.0	520.5
94	40 23.5 S	173 01.7 W	13 Feb 96	260.4	521.7
95	39 57.7 S	172 42.2 W	14 Feb 96	260.4	521.6
96	39 31.0 S	172 25.2 W	14 Feb 96	260.1	521.7
97	39 04.3 S	172 07.7 W	14 Feb 96	260.1	521.7
98	38 37.8 S	171 48.6 W	14 Feb 96	260.1	521.7
99	38 11.4 S	171 30.2 W	15 Feb 96	260.1	521.7
100	37 45.8 S	171 12.0 W	15 Feb 96	260.1	521.7
101	37 18.6 S	170 53.7 W	15 Feb 96	260.1	521.7
102	36 52.3 S	170 37.0 W	15 Feb 96	260.1	521.7
103	36 27.0 S	170 17.2 W	16 Feb 96	260.8	521.9

STATION NUMBER	Latitude	Longitude	Date	F11 PPT	F12 PPT
104	36 00.2 S	170 00.3 W	16 Feb 96	260.8	521.9
105	35 40.3 S	170 00.9 W	16 Feb 96	260.8	521.9
106	35 20.0 S	170 00.1 W	16 Feb 96	260.8	521.9
107	35 00.5 S	169 59.6 W	17 Feb 96	260.8	521.9
108	34 30.2 S	170 00.2 W	17 Feb 96	260.8	521.9
109	33 59.8 S	169 60.0 W	17 Feb 96	260.8	521.9
110	33 29.9 S	170 00.1 W	18 Feb 96	260.8	521.9
111	33 00.1 S	170 00.1 W	18 Feb 96	260.8	521.9
112	32 30.1 S	170 00.1 W	18 Feb 96	260.8	521.9
113	31 59.8 S	169 59.8 W	18 Feb 96	260.8	521.9
114	31 30.0 S	169 59.3 W	19 Feb 96	260.6	521.7
115	31 00.4 S	169 59.7 W	19 Feb 96	260.6	521.9
116	30 30.3 S	169 59.8 W	19 Feb 96	260.6	521.9
117	30 00.2 S	169 59.8 W	19 Feb 96	260.6	521.9
118	29 30.2 S	169 59.8 W	20 Feb 96	260.6	521.9
119	29 00.8 S	169 59.9 W	20 Feb 96	260.6	521.9
120	28 30.5 S	169 59.8 W	20 Feb 96	260.6	521.9
121	28 00.3 S	169 59.6 W	21 Feb 96	260.6	521.9
122	27 30.1 S	170 00.1 W	21 Feb 96	260.6	521.9
123	27 00.3 S	169 59.5 W	21 Feb 96	260.8	522.1
124	26 29.7 S	169 59.4 W	21 Feb 96	260.6	521.9
125	26 00.3 S	169 59.7 W	22 Feb 96	260.6	521.9
126	25 30.0 S	169 60.0 W	22 Feb 96	260.6	521.9
127	25 00.1 S	169 59.9 W	22 Feb 96	260.9	522.3
128	24 30.1 S	170 00.1 W	23 Feb 96	260.9	522.3
129	23 59.8 S	170 00.1 W	23 Feb 96	261.3	522.7
130	23 30.1 S	170 00.1 W	23 Feb 96	261.3	522.7
131	22 59.8 S	169 59.7 W	23 Feb 96	261.3	522.7
132	22 30.0 S	169 59.9 W	24 Feb 96	261.3	522.7
133	22 00.0 S	169 59.9 W	24 Feb 96	261.3	522.7
134	21 30.4 S	170 00.1 W	24 Feb 96	261.3	522.7
135	20 59.7 S	169 59.6 W	25 Feb 96	262.1	524.4
136	20 29.9 S	170 00.1 W	25 Feb 96	262.1	524.4
137	20 00.0 S	170 00.1 W	25 Feb 96	262.1	524.4
138	19 29.9 S	170 00.1 W	25 Feb 96	262.1	524.4
139	19 00.1 S	170 03.4 W	26 Feb 96	262.1	524.4
140	18 30.3 S	170 00.1 W	26 Feb 96	262.1	524.4
141	17 60.0 S	169 60.0 W	26 Feb 96	262.1	524.4
142	17 30.1 S	169 60.0 W	26 Feb 96	262.1	524.4
143	17 00.1 S	169 59.8 W	27 Feb 96	262.3	525.0
144	16 30.3 S	169 59.9 W	27 Feb 96	262.7	525.9
145	16 00.2 S	169 59.9 W	27 Feb 96	262.7	525.9
146	15 29.8 S	170 00.1 W	27 Feb 96	262.8	525.6
147	15 00.2 S	170 00.0 W	28 Feb 96	262.8	525.6
148	14 40.0 S	169 59.9 W	28 Feb 96	262.9	525.5
149	14 16.9 S	169 59.8 W	28 Feb 96	262.9	525.5
150	13 58.3 S	169 60.0 W	28 Feb 96	262.9	525.5
151	13 49.1 S	170 00.1 W	28 Feb 96	262.9	525.5
152	13 30.1 S	169 60.0 W	29 Feb 96	262.9	525.5
153	12 59.9 S	170 00.0 W	29 Feb 96	262.9	525.5
154	12 29.9 S	169 59.9 W	29 Feb 96	262.9	525.5
155	12 00.1 S	170 00.1 W	29 Feb 96	262.9	525.5
156	11 30.0 S	169 59.9 W	1 Mar 96	262.9	525.5
157	11 00.1 S	169 59.9 W	1 Mar 96	262.9	525.5

STATION NUMBER	Latitude	Longitude	Date	F11 PPT	F12 PPT
158	10 30.1 S	169 59.8 W	1 Mar 96	262.9	525.5
159	09 55.6 S	169 37.7 W	1 Mar 96	262.6	525.3
160	09 30.1 S	168 59.9 W	2 Mar 96	262.6	525.3
161	08 59.9 S	168 52.6 W	2 Mar 96	262.6	525.0
162	08 29.9 S	168 44.9 W	2 Mar 96	262.6	525.0
163	08 00.0 S	168 37.0 W	2 Mar 96	262.6	525.0
164	07 30.1 S	168 44.9 W	3 Mar 96	262.6	525.0
165	06 60.0 S	168 44.9 W	3 Mar 96	262.8	526.1
166	06 30.1 S	168 44.9 W	3 Mar 96	262.7	526.5
167	06 00.0 S	168 45.0 W	4 Mar 96	262.7	526.5
168	05 30.1 S	168 45.0 W	4 Mar 96	262.7	526.5
169	05 00.0 S	168 44.9 W	4 Mar 96	262.7	526.5
170	03 60.0 S	168 45.1 W	4 Mar 96	262.7	526.5
171	03 00.0 S	168 45.0 W	5 Mar 96	263.0	527.3
172	02 00.1 S	168 45.0 W	5 Mar 96	263.5	528.4
173	01 00.1 S	168 45.2 W	6 Mar 96	263.5	528.4
174	00 00.1 S	168 45.0 W	6 Mar 96	263.5	528.4
175	07 44.8 S	168 40.2 W	8 Mar 96	262.7	526.5
176	08 15.1 S	168 41.3 W	8 Mar 96	262.7	526.5
177	10 08.7 S	168 58.8 W	8 Mar 96	262.7	526.5
178	10 04.1 S	169 12.7 W	8 Mar 96	262.7	526.5
179	09 55.2 S	169 37.7 W	9 Mar 96	262.7	526.5
180	09 47.0 S	170 03.5 W	9 Mar 96	262.7	526.5
181	09 41.6 S	170 19.5 W	9 Mar 96	262.7	526.5
182	09 35.7 S	170 36.1 W	9 Mar 96	262.7	526.5

Appendix 2b: Replicate CFC-11 measurements

STATION NUMBER	SAMP NO.	F11 pM/kg	F11 Stdev
1	112	0.092	0.007
4	110	4.157	0.012
5	113	4.117	0.008
9	202	0.136	0.015
9	234	4.672	0.035
10	201	0.155	0.003
10	211	0.050	0.001
10	214	0.095	0.004
11	101	0.148	0.007
14	101	0.143	0.000
14	134	4.542	0.030
15	201	0.144	0.001
15	234	4.674	0.009
16	101	0.148	0.002
16	110	0.047	0.003
17	103	0.134	0.002
17	133	5.035	0.037
18	134	4.864	0.061
21	123	5.464	0.042
25	110	0.087	0.001
28	101	0.180	0.005
28	112	0.226	0.001
28	124	6.359	0.131
29	201	0.496	0.001
29	212	0.250	0.001
29	230	6.393	0.097
30	101	1.373	0.007
30	133	6.172	0.033
31	203	1.422	0.021
31	225	0.662	0.019
32	111	0.091	0.006
32	115	0.124	0.006
33	103	0.664	0.002
33	131	4.790	0.014
34	101	0.579	0.006
34	103	0.542	0.001
34	107	0.190	0.003
35	101	0.524	0.004
35	103	0.512	0.000
35	133	6.287	0.029
39	101	0.128	0.001
39	121	6.277	0.107
39	124	6.638	0.087
40	101	0.108	0.005
40	133	6.720	0.006
41	103	0.077	0.007
41	133	6.678	0.030
42	101	0.093	0.001
42	133	6.521	0.013
43	111	0.186	0.000
43	120	5.799	0.006
45	110	0.184	0.002
45	115	1.009	0.013
45	123	5.791	0.022
46	103	0.049	0.007
46	129	5.699	0.029
48	101	0.060	0.001
48	110	0.034	0.001
49	101	0.080	0.001
49	111	0.044	0.005
49	120	0.727	0.001
49	129	4.880	0.019
50	104	0.045	0.008
50	116	0.198	0.008
50	132	5.214	0.038
52	101	0.090	0.000
52	110	0.040	0.009
52	113	0.058	0.002
52	121	1.006	0.009
52	132	5.044	0.006
53	103	0.084	0.003
53	125	3.138	0.019
54	102	0.082	0.007
54	114	0.074	0.000
54	132	4.758	0.088
56	103	0.078	0.000
56	111	0.039	0.001
56	132	4.654	0.025
57	103	0.073	0.004
58	211	0.035	0.006
58	232	4.508	0.036
61	103	0.086	0.006
61	113	0.083	0.003
61	123	3.373	0.011
61	131	4.015	0.003
62	203	0.068	0.003
63	103	0.052	0.002
63	122	4.015	0.021
65	101	0.090	0.002
65	110	0.103	0.003
65	114	2.096	0.021
65	122	4.111	0.004
66	101	0.082	0.001
66	133	3.836	0.007
67	202	0.071	0.000
67	233	3.457	0.002
68	102	0.067	0.003
69	201	0.080	0.001
69	231	3.791	0.000
70	101	0.072	0.001
70	107	0.026	0.000
71	104	0.051	0.001

STATION NUMBER	SAMP NO.	F11 pM/kg	F11 Stdev
71	128	4.000	0.007
72	101	0.084	0.003
73	103	0.070	0.005
73	115	0.290	0.003
73	133	3.444	0.008
74	202	0.088	0.006
75	102	0.095	0.001
75	128	3.592	0.027
76	201	0.101	0.003
76	203	0.082	0.001
76	208	0.037	0.003
77	102	0.089	0.000
77	112	0.063	0.002
77	133	3.101	0.001
78	101	0.094	0.005
79	102	0.045	0.001
79	132	2.876	0.002
80	203	0.030	0.004
81	109	0.796	0.004
83	101	0.372	0.002
83	105	1.986	0.003
86	101	0.199	0.006
87	101	0.030	0.003
88	101	0.016	0.001
88	104	0.005	0.001
88	113	1.807	0.007
88	125	3.050	0.021
89	202	0.018	0.000
89	206	0.012	0.003
89	232	2.466	0.001
90	103	0.012	0.003
92	201	0.054	0.004
93	102	0.058	0.000
94	102	0.055	0.002
94	112	0.009	0.002
94	130	2.911	0.013
95	101	0.065	0.000
96	102	0.055	0.001
96	119	0.344	0.008
96	135	2.563	0.001
97	201	0.068	0.002
98	102	0.046	0.002
98	134	2.506	0.007
100	101	0.067	0.006
100	118	0.095	0.000
101	227	2.735	0.014
102	102	0.031	0.000
102	124	1.114	0.008
104	101	0.029	0.001
104	132	3.014	0.022
105	201	0.018	0.002
105	203	0.006	0.001
105	205	0.002	0.002
106	102	0.029	0.000

STATION NUMBER	SAMP NO.	F11 pM/kg	F11 Stdev
106	134	2.344	0.013
108	101	0.024	0.002
108	134	2.594	0.013
109	101	0.021	0.001
110	202	0.016	0.001
110	234	2.336	0.023
112	102	0.020	0.000
112	132	2.632	0.008
113	101	0.015	0.000
114	104	0.012	0.000
114	135	2.035	0.006
115	101	0.014	0.001
116	201	0.013	0.001
116	204	0.012	0.000
116	223	0.596	0.005
116	234	1.946	0.007
117	101	0.013	0.002
117	107	0.005	0.000
118	103	0.011	0.000
118	128	2.240	0.001
119	103	0.014	0.002
120	201	0.012	0.000
120	205	0.008	0.001
120	227	1.996	0.040
120	234	2.237	0.008
121	201	0.010	0.001
122	102	0.011	0.000
122	105	0.004	0.002
122	132	2.404	0.000
123	101	0.009	0.000
124	101	0.009	0.000
124	130	2.283	0.015
124	135	1.766	0.003
125	303	0.009	0.001
125	334	1.959	0.018
126	101	0.008	0.001
126	132	2.142	0.012
127	201	0.013	0.000
127	210	0.001	0.001
127	226	1.524	0.002
127	235	1.814	0.013
128	201	0.013	0.002
129	102	0.009	0.000
129	135	1.755	0.020
130	101	0.011	0.001
130	107	0.007	0.001
130	125	1.222	0.006
131	134	1.935	0.008
132	102	0.013	0.001
132	119	0.003	0.001
132	133	1.930	0.011
133	101	0.011	0.001
134	201	0.012	0.000
134	235	1.630	0.005

STATION NUMBER	SAMP NO.	F11 pM/kg	F11 Stdev
135	201	0.013	0.002
135	215	-0.001	0.000
135	234	1.919	0.001
136	103	0.010	0.000
137	101	0.011	0.002
137	121	0.003	0.002
137	133	1.892	0.002
140	102	0.009	0.000
140	133	1.872	0.004
141	101	0.011	0.001
142	102	0.015	0.002
142	123	0.071	0.000
142	135	1.641	0.007
143	101	0.011	0.000
144	102	0.006	0.001
144	129	1.962	0.011
145	103	0.005	0.002
146	102	0.007	0.001
146	125	0.351	0.001
146	131	1.827	0.011
147	101	0.009	0.000
148	121	0.719	0.000
150	234	1.566	0.003
151	102	0.006	0.001
151	135	1.552	0.018
152	101	0.007	0.002
153	102	0.006	0.000
153	132	1.689	0.002
154	101	0.006	0.001
154	103	0.006	0.000
155	102	0.006	0.000
155	122	0.009	0.001
155	134	1.566	0.003
156	102	0.008	0.002
157	104	0.004	0.001

STATION NUMBER	SAMP NO.	F11 pM/kg	F11 Stdev
158	102	0.006	0.000
159	102	0.008	0.002
159	103	0.005	0.001
159	134	1.553	0.012
160	103	0.006	0.001
161	103	0.003	0.001
161	131	1.715	0.014
162	201	0.005	0.001
163	201	0.005	0.000
163	229	1.620	0.002
164	104	0.002	0.001
166	201	0.003	0.001
167	201	0.003	0.002
167	230	1.936	0.007
169	201	0.004	0.001
169	226	0.055	0.002
169	235	1.666	0.013
170	101	0.004	0.001
170	129	1.045	0.003
171	101	0.005	0.001
171	128	0.343	0.003
172	221	0.176	0.000
172	233	1.741	0.001
173	201	0.003	0.002
173	225	0.056	0.004
173	231	1.689	0.001
174	101	-0.000	0.000
175	204	0.003	0.000
176	101	0.005	0.001
177	101	0.003	0.000
177	104	0.000	0.000
178	101	0.005	0.000
179	101	0.005	0.000
180	101	0.005	0.001
181	101	0.006	0.000
182	101	0.006	0.001

Appendix 2c: Replicate CFC-12 measurements

STATION NUMBER	SAMP NO.	F12 pM/kg	F12 Stdev
1	112	0.043	0.007
4	110	2.188	0.007
5	113	2.131	0.012
9	202	0.070	0.007
9	234	2.408	0.013
10	201	0.080	0.003
10	214	0.050	0.002
11	101	0.083	0.010
14	101	0.070	0.001
14	134	2.317	0.007
15	201	0.072	0.002
15	234	2.395	0.011
16	101	0.070	0.003
16	110	0.021	0.002
17	103	0.066	0.001
17	133	2.571	0.031
18	134	2.457	0.015
21	123	2.772	0.035
25	110	0.038	0.004
28	101	0.082	0.003
28	112	0.106	0.001
28	124	3.075	0.054
29	201	0.228	0.003
29	212	0.115	0.002
29	230	3.072	0.048
30	101	0.646	0.013
30	133	2.976	0.021
31	203	0.682	0.008
31	225	0.415	0.084
33	103	0.321	0.003
33	131	2.343	0.018
34	101	0.286	0.001
34	103	0.306	0.033
34	107	0.104	0.004
35	101	0.265	0.008
35	103	0.245	0.001
35	133	3.094	0.002
39	101	0.061	0.001
39	121	3.011	0.075
39	124	3.165	0.026
40	101	0.064	0.004
40	133	3.191	0.001
41	103	0.039	0.003
41	133	3.186	0.005
42	101	0.053	0.002
42	133	3.133	0.007
43	111	0.090	0.004
43	120	2.826	0.011
45	101	0.033	0.002
45	110	0.088	0.008
45	115	0.472	0.002
45	123	2.837	0.029
46	103	0.025	0.001
46	129	2.800	0.030
48	101	0.028	0.001
48	110	0.025	0.002
49	101	0.040	0.001
49	111	0.027	0.004
49	120	0.349	0.003
49	129	2.413	0.021
50	104	0.027	0.000
50	116	0.097	0.001
50	132	2.642	0.018
52	101	0.044	0.001
52	110	0.021	0.006
52	113	0.030	0.004
52	121	0.476	0.008
52	132	2.556	0.008
53	103	0.046	0.000
53	125	1.531	0.004
54	102	0.044	0.002
54	114	0.042	0.008
54	132	2.414	0.032
56	103	0.043	0.004
56	111	0.021	0.001
56	132	2.422	0.007
57	103	0.032	0.002
58	211	0.019	0.001
58	232	2.323	0.020
61	103	0.038	0.005
61	113	0.041	0.002
61	123	1.680	0.011
61	131	2.128	0.030
62	203	0.034	0.004
63	103	0.028	0.000
63	122	2.119	0.011
65	101	0.049	0.003
65	110	0.050	0.002
65	114	1.009	0.016
65	122	2.133	0.012
66	101	0.046	0.008
66	133	2.050	0.001
67	202	0.040	0.000
67	233	1.864	0.013
68	102	0.037	0.002
69	201	0.041	0.001
69	231	2.000	0.005
70	101	0.039	0.003
70	107	0.014	0.001
71	104	0.032	0.001
72	101	0.045	0.000
73	103	0.043	0.002

STATION NUMBER	SAMP NO.	F12 pM/kg	F12 Stdev
73	115	0.144	0.000
73	133	1.841	0.009
74	202	0.056	0.007
75	128	1.863	0.011
76	201	0.053	0.004
76	203	0.059	0.004
77	102	0.058	0.002
77	133	1.695	0.012
78	101	0.076	0.007
79	132	1.610	0.013
81	109	0.474	0.008
83	101	0.235	0.007
83	105	1.014	0.014
86	101	0.153	0.005
88	113	0.959	0.018
88	125	1.701	0.001
89	232	1.394	0.025
90	103	0.004	0.003
93	102	0.035	0.001
94	102	0.031	0.004
94	130	1.535	0.001
95	101	0.034	0.000
96	102	0.028	0.000
96	119	0.182	0.003
96	135	1.402	0.008
97	201	0.037	0.004
98	102	0.030	0.000
98	134	1.365	0.011
100	101	0.041	0.005
100	118	0.058	0.005
100	135	1.310	0.003
101	227	1.374	0.025
102	102	0.018	0.002
102	124	0.565	0.005
104	101	0.017	0.000
104	132	1.615	0.018
105	201	0.014	0.001
105	203	0.006	0.000
105	205	0.003	0.000
106	102	0.018	0.003
106	134	1.288	0.015
108	101	0.012	0.001
108	134	1.382	0.000
109	101	0.013	0.003
110	202	0.011	0.000
110	234	1.267	0.024
112	102	0.012	0.001
112	132	1.398	0.006
113	101	0.010	0.001
114	104	0.009	0.000
114	135	1.135	0.012
115	101	0.009	0.001
116	201	0.010	0.000
116	204	0.009	0.001
116	223	0.306	0.000
116	234	1.094	0.017
117	101	0.009	0.003
117	107	0.004	0.001
118	103	0.007	0.000
118	128	1.166	0.003
119	103	0.007	0.000
120	201	0.008	0.000
120	205	0.007	0.000
120	227	0.988	0.002
120	234	1.227	0.003
121	201	0.007	0.001
122	102	0.007	0.001
122	105	0.004	0.000
122	132	1.295	0.003
123	101	0.005	0.000
124	101	0.006	0.001
124	130	1.213	0.009
124	135	1.000	0.005
125	303	0.004	0.000
125	334	1.081	0.004
126	101	0.004	0.000
126	132	1.174	0.011
127	201	0.007	0.000
127	210	0.002	0.001
127	226	0.755	0.002
127	235	1.029	0.004
128	201	0.007	0.000
129	102	0.005	0.000
129	135	0.996	0.006
130	101	0.005	0.000
130	107	0.004	0.001
130	125	0.600	0.004
131	134	1.077	0.006
132	102	0.006	0.001
132	119	0.004	0.001
133	101	0.006	0.000
134	201	0.007	0.001
134	235	0.935	0.018
135	201	0.008	0.000
135	215	0.001	0.001
135	234	1.073	0.004
136	103	0.005	0.000
137	101	0.006	0.001
137	121	0.002	0.000
137	133	1.059	0.005
140	102	0.004	0.000
140	133	1.056	0.003
141	101	0.006	0.000
142	102	0.006	0.001
142	123	0.045	0.007
142	135	0.946	0.012
143	101	0.005	0.001
144	102	0.003	0.000

STATION NUMBER	SAMP NO.	F12 pM/kg	F12 Stdev
144	129	1.056	0.009
145	103	0.002	0.001
146	102	0.003	0.001
146	125	0.192	0.003
146	131	1.012	0.006
147	101	0.003	0.000
148	121	0.369	0.007
150	234	0.914	0.004
151	102	0.001	0.002
151	135	0.888	0.006
152	101	0.005	0.002
153	102	0.003	0.000
153	132	0.946	0.003
154	101	0.001	0.002
154	103	0.001	0.000
155	102	0.002	0.001
155	122	0.004	0.001
155	134	0.892	0.013
156	102	0.003	0.001
157	104	0.001	0.000
158	102	0.003	0.001
159	102	0.002	0.000
159	103	0.002	0.001
159	134	0.910	0.038
160	103	0.002	0.001
161	103	0.000	0.001

STATION NUMBER	SAMP NO.	F12 pM/kg	F12 Stdev
161	131	0.935	0.008
162	201	0.003	0.000
163	201	0.002	0.001
163	229	0.848	0.001
164	104	0.000	0.001
167	201	0.002	0.000
167	230	1.042	0.006
169	201	0.002	0.001
169	226	0.029	0.002
169	235	0.937	0.004
170	101	0.009	0.000
170	129	0.551	0.002
171	101	0.000	0.001
171	128	0.180	0.002
172	221	0.089	0.001
172	233	0.949	0.006
173	201	0.000	0.000
173	225	0.020	0.002
173	231	0.879	0.007
174	101	0.000	0.000
178	101	0.003	0.000
179	101	0.002	0.000
180	101	0.004	0.002
181	101	0.004	0.000
182	101	0.004	0.001

B.4. Carbon Measurement Techniques

B.4.1 pH

Seawater samples were drawn from the PVC bottles with a 25-cm length of silicon tubing. One end of the tubing was fit over the petcock of the PVC bottle and the other end was attached over the opening of a 10-cm glass spectrophotometric cell. The spectrophotometric cell was rinsed three to four times with a total volume of approximately 200 mL of seawater; the Teflon(tm) endcaps were also rinsed and then used to trap a sample of seawater in the glass cell. While drawing the sample, care was taken to make sure that no air bubbles were trapped within the cell.

Seawater pH was measured using a three-wavelength spectrophotometric procedure (Byrne, 1987) and the indicator calibration of Clayton and Byrne (1993). The indicator was a 8.0-mM solution of Kodak(tm) m-cresol purple sodium salt (C21H17O5Na) in a 10% ethanol solution; the absorbance ratio of the concentrated indicator solution (RI = 578A/434A) was 1.00. All absorbance ratio measurements were obtained in the thermostated (25.0 +/- 0.05°C) cell compartments of HP 8453 diode array spectrophotometers. Periodically the spectrophotometric cells were cleaned with a 1 N HCl solution to preclude biological growth. Measurements of pH were taken at 25.0°C on the total hydrogen ion concentration ([H+]t) scale, in mol/kg soln.

B.4.2 Dissolved Inorganic Carbon (DIC)

The DIC analytical equipment was set up in a seagoing container modified for use as a laboratory. The analysis was done by coulometry; two analytical systems were used simultaneously on the cruise, each consisting of a coulometer (UIC, Inc.) coupled with a SOMMA (Single Operator Multiparameter Metabolic Analyzer) inlet system developed by Ken Johnson (Johnson et al., 1985,1987,1993; Johnson, 1992) of Brookhaven National Laboratory (BNL). Pipette volume was determined based on the procedures described in Handbook of Methods for CO2 Analysis (DOE, 1994).

In the coulometric analysis of DIC, all carbonate species are converted to CO_2 (gas) by addition of excess hydrogen to the seawater sample, and the evolved CO_2 gas is carried into the titration cell of the coulometer, where it reacts quantitatively with a proprietary reagent based on ethanolamine to generate hydrogen ions. These are subsequently titrated with coulometrically generated OH-. CO_2 is thus measured by integrating the total charge required to achieve this. Samples were drawn from the PVC bottles into cleaned, precombusted 500-mL Pyrex(tm) bottles using Tygon(tm) tubing according to procedures outlined in the Handbook of Methods for CO_2 Analysis (DOE, 1994). Bottles were rinsed once and filled from the bottom, overflowing half a volume, and care was taken not to entrain any bubbles. The tube was pinched off and withdrawn, creating a 5-mL headspace, and 0.2 mL of saturated HgCl2 solution was added as a preservative.

The sample bottles were sealed with glass stoppers lightly covered with Apiezon-L(tm) grease, and were stored at room temperature for a maximum of 12 hours prior to analysis.

The coulometers were calibrated by injecting aliquots of pure CO_2 (99.995%) by means of an 8-port valve outfitted with two sample loops that had been calibrated at BNL (Wilke, 1993). All DIC values were corrected for dilution by 0.2 mL of HgCl2; total water volume was 540 mL. The correction factor used was 1.00037. The instruments were calibrated at the beginning, middle, and end of each coulometer cell solution with a set of the gas loop injections.

CRMs (Batch 29) were provided by Dr. Andrew Dickson (SIO), and was analyzed on both instruments over the duration of the cruise. The CRM certified value was 1902.54 +/-1.05 (n=14).

The overall accuracy and precision for the CRMs on both instruments combined was -1.1 +/-0.9 (n=153). Replicate measurements from different PVC bottles tripped at the same depth, along with replicate measurements from the same PVC bottle was within +/-1.9 mol/kg DIC. DIC data reported for this cruise have been corrected to the Batch 29 CRM value by adding the difference between the certified value and the mean shipboard CRM value (certified value - shipboard analyses) on a per instrument/per leg basis.

B.4.3. Total Alkalinity (TA)

The titration system used to determine TA consisted of a Metrohm 665 Dosimat® titrator and an Orion(tm) 720A pH meter controlled by a personal computer (Millero et al., 1993). The acid titrant, in a water-jacketed burette, and the seawater sample, in a water-jacketed cell, were kept at 25 +/- 0.1°C with a Neslab® constant-temperature bath. The Plexiglas water-jacketed cells were similar to those used by Bradshaw et al. (1988), except that a larger volume (200 mL) was used to increase the precision. The cells had fill and drain valves with zero dead-volume to increase the reproducibility of the cell volume.

The HCl solutions used throughout the cruise were made, standardized, and stored in 500-mL glass bottles in the laboratory for use at sea. The 0.2487 M HCl solutions were made from 1 M Mallinckrodt(tm) standard solutions in 0.45 M NaCl to yield an ionic strength equivalent to that of average seawater (0.7 M). The acid was independently standardized using a coulometric technique (Taylor and Smith, 1959; Marinenko and Taylor, 1968) by the University of Miami and by Dr. Dickson. The two standardization techniques agreed to +/-0.0001 N.

The volume of HCl delivered to the cell is traditionally assumed to have a small uncertainty (Dickson, 1981) and is equated with the digital output of the titrator. Calibrations of the Dosimat® burettes with Milli Q(tm) water at 25°C indicated that the systems deliver 3.000 mL (the value for a titration of seawater) to a precision of 0.0004 mL. This uncertainty resulted in an error of 0.4 mol/kg in TA.

Internal consistency of each cell was checked before, during, and after the cruise by titrating CRM Batches 29 and 30 prepared by Dr. Dickson. The TA of CRM was determined by open cell (weighed) titration in the laboratory prior to the cruise and was found to be 2184.8 +/- 1.3 mol/kg (n= 15) and 2201.9 +/- 1.0 mol/kg (n = 21), respectively. A total of 85 CRM measurements made at sea yielded 2173.8 +/- 1.6 mol/kg for Batch 29 and 2190.8 +/- 1.7 mol/kg for Batch 30 on three different cells. This offset was due to changes in the volume of the cells. All TA data have been corrected to laboratory CRM values for each cell and each leg.

B.4.4 Discrete fCO_2 (fugacity of CO_2) Measurements

Principal Investigator: Rik Wanninkhof (Wanninkhof@aoml.noaa.gov)
Analysts: Dana Greeley and Hua Chen
Note: all data is fCO_2 data but labeled as pCO_2

Approximately 2900 discrete fCO_2 samples from 168 station were taken and analyzed on the cruise using an analysis system based on gas chromatography (Neill et al., 1997). The measurement was performed by equilibrating 10-mL headspace with 120-mL seawater sample at 20°C in a bottle with crimp seal and Teflon lined cap. The headspace was injected into a gas chromatographic column that separates CO_2 from the other gases in the headspace. The CO_2 is subsequently quantitatively converted to methane using a ruthenium catalyst. The methane is measured at high sensitivity with a flame ionization detector.

The data obtained from the cruise has an uncertainty proportional to the gas concentration in contrast to our previous system that was based on infrared analysis using larger samples (Wanninkhof and Thoning, 1993). The current system has slightly worse precision for surface water samples but better precision for samples with high pCO_2. During leg 1, 38 duplicate samples had a precision of 0.9 % (1- st. dev.); during leg 2, 41 duplicates yielded a precision of 1%.

The quality control steps were as follows. All samples that had sampling irregularities such as leakage, detachment of the sample bottle from the intake line etc. were flagged as questionable during analysis on the cruise. During data reduction the following checks were performed:

(1) Plotting fCO_2 against depth

(2) Plotting fCO_2 against DIC

(3) Plotting fCO_2 against pH

(4) Performing internal consistency calculations using the Lewis and Wallace (1998) program and calculating TA(TC,fCO_2) and TA(TC,pH) and {TA(meas)- TA(TC,fCO_2)} and {TA(meas)- TA(TC,pH)}. These differences were then plotted for four consecutive stations against depth.

Based on these comparisons a subjective assessment was made as to the quality of the data and quality control flags were adjusted as deemed proper.

fCO_2 References

Lewis, E., and D.W.R. Wallace, Program developed for CO_2 system calculations, Oak Ridge National Laboratory, Oak Ridge, 1998.

Neill, C., K.M. Johnson, E. Lewis, and D.W.R. Wallace, Small volume, batch equilibration measurement of fCO_2 in discrete water samples., Limnol. Oceanogr., 42, 1774-1783, 1997.

Wanninkhof, R., and K. Thoning, Measurement of fugacity of CO_2 in surface water using continuous and discrete sampling methods, Mar. Chem., 44 (2-4), 189-205, 1993.

Appendix 3: Listing of CGC96 Bottle problems, with QC evaluations

* indicates no nutrient sample.

Stn Nbr	Samp no	Cast no	initial Fbtl nbr	Ctdprs	Problem as annotated; on deck logs	Comments	fbtlnbr re-set to:
1	106	1	3	3001.9	Leaking, *	ctd-sal < .001,no O2,cfc,sil	2
2	110	1	3	3997.2	Leaking, *	ctd-sal = 0,no O2,cfc,sil	2
2	121	1	3	1600.5	Leaking, *	ctd-sal < .0014,no O2,sil, cfc=good	2
2	129	1	3	2235.5	Leaking, *	no sal,O2,cfc,sil	3
2	133	1	3	2236.5	Leaking, *	no sal,O2,sil cfc=OK	3
3	129	1	3	37.5	Leaking, *	NO BOTTLE DATA FO STA=3	3
4	104	1	3	117.7	Leaking, high nutrients	ctd-sal < .001, O2=OK,cfc=OK,sil=high	3
4	109	1	3	9.3	Leaking	ctd-sal = -.0085,O2=OK, cfc=OK	2
5	107	1	3	465.9	Stopcock pushed in	ctd-sal < 0.001,no O2,cfc	3
5	113	1	3	207.4	Leaking	ctd-sal = -.0011,others=OK	2
5	114	1	3	180.8	Top endcap cracked	ctd-sal=0.001,sil=OK,no cfc,O2	3
6	103	1	4	1070.5	Did not trip properly, *	no samples	4
6	110	1	3	490.8	Leaking	ctd-sal=-0.0004,sil=OK, no others	2
7	108	1	3	724.9	Leaking	ctd-sal=.0003,O2,sil=OK,no cfc	2
7	120	1	3	154.8	Leaking	ctd-sal=.0003,O2,sil=OK, no cfc	2
8	108	1	3	1213.6	Huge Leak at top cap, *	ctd-sal=.0007,no O2,cfc,sil	3
8	132	1	3	11.1	Stopcock open, 131/132	nut reps look OK ctd-sal=0.0001,O2=OK,no cfc	3
11	103	1	3	5120	Stopcock pushed in,102/103	nut reps=ok ctd-sal=-.0006,O2,nuts=OK,no cfc	2
11	117	1	3	1317.8	Leaking, *	no sal,nuts,cfc; O2=high BAD	3
12	203	2	4	4900.2	no comment	ctd-sal=0.5,nuts-very low, O2=very high	fbtlnbr 4
12	206	2	3	3699.8	Leaking	ctd-sal=0.0009,O2,sil=OK	2
12	209	2	3	2504.4	Leaking	ctd-sal=.0017,O2,sil=OK	2
13	106	1	3	3498.8	Leaking	ctd-sal=0.0010,no O2,cfc,sil=OK	2
13	109	1	3	2293.5	Leaking	ctd-sal=0.0017,no O2,cfc;sil=OK	2
14	117	1	3	1214	Leaking, *	no sal,cfc,sil;O2 a little high?	3
15	208	2	3	3561.8	Leaking	ctd-sal=0.0013;no cfc;O2,sil=OK	2
15	213	2	3	2316.3	Band broken on btm	ctd-sal=0.001;O2,cfc,sil=OK	2
15	217	2	3	1310	Leaking, *	no sal,cfc,nuts; O2=high	3
15	225	2	3	427.1	Stopcock pushed in	ctd-sal=-0.0009;no cfc,sil;O2-ctd=low	3
15	233	2	4	31.2	Did not trip, *		4
16	109	1	3	3188.9	Leaking	ctd-sal=0.0010;O2,sil=OK,no cfc	2
16	117	1	3	1224.3	Leaking	ctd-sal=0.0015;O2,sil=OK,no cfc	2

* indicates no nutrient sample.

Stn Nbr	Samp no	Cast no	initial Fbtl nbr	Ctdprs	Problem as annotated; on deck logs	Comments	fbtlnbr re-set to:
17	120	1	3	926.4	Leaking	ctd-sal=0.00008;O2,cfc,sil=OK	2
17	131	1	3	78.5	Leaking	ctd-sal=0.0012;O2,sil=OK;no cfc	2
18	103	1	3	4878.1	Leaking	ctd-sal=0.0013;O2,sil,cfc=OK;ph?	3
18	133	1	4	19.4	Did not close, *		4
19	106	1	3	3093.8	Leaking	ctd-sal=-0.0012;f12 a little high,no pH	2
19	110	1	3	1504.9	Leaking	ctd-sal=0.0029;	2
19	117	1	3	420.1	Stopcock pushed in *		3
20	105	1	4	2889.9	Empty, *		4
20	106	1	3	2502.3	Leaking	ctd-sal <0.001;sil=OK	3
20	109	1	3	1355.7	Damaged bottle		3
20	114	1	3	577	Stopcock pushed in		3
21	103	1	4	4702.5	Did not trip properly, *		4
21	106	1	3	3502	Leaking, PO4 high, sil & NO3 ok	ctd-sal=0.0009;cfc,sil=OK	2
21	122	1	4	67.2	Empty, *		4
22	205	2	4	3300.8	Did not trip properly, *	no sal,O2,cfc,sil	4
22	206	2	3	2899.0	Did not trip properly, *	ctd-sal=0.0049;no cfc;O2,sil=OK	3
23	109	1	3	2299.5	Vent open	ctd-sal=0.0010;O2,cfc,sil=OK	2
23	115	1	3	603	Bottom open, *		4
25	104	1	3	3496.2	Stopcock pushed in	ctd-sal<<0.001;cfc,O2,sil,ph=OK	2
25	105	1	4	3096.6	Did not trip properly, *		4
27	111	1	4	722.4	Did not close-lanyard hung up, *		4
28	117	1	3	191.3	Stopcock pushed in	ctd-sal=-0.001;O2,sil=OK;no cfc	2
29	209	2	3	1029.4	Leaking	ctd-sal=0.0011;no cfc,O2;sil=OK	2
29	220	2	3	269.6	Leaking	ctd-sal=0.0002;sil,O2=OK;no cfc	2
29	226	2	3	106.1	Leaking	ctd-sal=0.0025;sil,O2,cfc=OK	2
30	104	1	3	3185.7	Leaking	ctd-sal=0.0003;sil,O2,cfc=OK	2
30	120	1	3	436.3	Leaking	ctd-sal = 0.0006;no cfc;O2,sil=OK	2
31	229	2	4	-9	Did not trip properly, *		4
31	230	2	4	-9	Did not trip properly, *		4
31	231	2	4	-9	Did not trip properly, *		4
31	232	2	4	-9	Did not trip properly, *		4
31	233	2	4	-9	Did not trip properly, *		4
31	234	2	4	-9	Did not trip properly, *		4
32	131	1	3	45.1	Leaking		3
33	113	1	3	1136.4	Stopcock pushed in	ctd-sal=-0.0002;O2,cfc,sil,ph=OK	2

* indicates no nutrient sample.

Stn Nbr	Samp no	Cast no	initial Fbtl nbr	Ctdprs	Problem as annotated; on deck logs	Comments	fbtlnbr re-set to:
34	110	1	3	1439.2	Leaking	ctd-sal=0.0004;O2,sil=OK;no cfc,ph	2
35	131	1	3	59.1	Leaking	ctd-sal=0.0176;no cfc,O2;sil=OK	3
36	101	1	3	2901	Stopcock pushed in	no sal,cfc;O2,sil,ph=OK	3
36	102	1	3	2752.2	Stopcock pushed in	no sal,cfc;O2,sil,ph=OK	3
37	107	1	3	1030.9	Top may be been cracked by tag lines	ctd-sal=0.0002;O2,sil,cfc,ph=OK	2
37	108	1	3	921	Top may be been cracked by tag lines	ctd-sal=0.0002;O2,sil,cfc,ph=OK	2
37	109	1	3	820	Top may be been cracked by tag lines	ctd-sal=0.0067	3
38	103	1	3	2099.4	Stopcock pushed in	ctd-sal=-0.0012;O2,sil,ph=OK;no cfc;	2
38	122	1	3	41.4	Leaking	ctd-sal=-0.0051;sil=OK;no cfc,ph,O2	2
39	104	1	3	1897.4	Stopcock pushed in	ctd-sal=-0.0005;O2,sil,ph=OK;no cfc	2
39	109	1	3	919.5	Stopcock pushed in	no sal,cfc;sil,ph,O2=OK	3
40	131	1	3	43.3		ctd-sal=-0.0025;O2,ph,sil=OK;no cfc	2
40	134	1	3	10.7	bottom leaking	ctd-sal=-0.0034;sil=OK;no cfc,O2,ph	2
41	130	1	3	8.3	Leaking	ctd-sal=-0.0036;sal,O2,sil,ph=OK;no cfc	2
42	110	1	3	1693.4	Stopcock pushed in	ctd-sal=-0.0009;O2,sil=OK;no cfc,ph	2
42	131	1	3	45.1	Stopcock pushed in	ctd-sal = -0.0011;O2,sil=OK;no cfc,ph	2
43	103	1	3	2706.8	no comment	sal,O2,cfc,nuts flagged	3
45	120	1	3	166.3	Stopcock pushed in	ctd-sal=-0.0013;sil=OK;no cfc,ph,O2	3
46	126	1	3	193.2	Leaking	ctd-sal=-0.0010;O2,cfc,sil,ph=OK	2
46	131	1	3	67	Leaking	ctd-sal=0.0042;sil=OK;no cfc,ph	3
47	201	2	3	4100.7	Leaking	cts-sal=0.0011;O2-ctd high,sil=OK	3
47	231	2	3	82.1	Leaking	ctd-sal=-0.0006;O2,sil=OK	2
48	106					fO2=4 4% lower than surrounding points	
49	120	1	3	927	Stopcock pushed in	ctd-sal=0.0011;O2,cfc,sal=OK,no ph	2
50	101	1	3	4489.5	Leaking	ctd-sal=0.0008;O2,ph,sil=OK;no cfc	2
50	102					fO2=3:1.5% higher than rep and surrounding points	
50	111	1	3	2440	Leaking	ctd-sal=0.0013;O2,cfc,sil,ph=OK	2
50	114	1	3	1661.4	Leaking	ctd-sal=0.0004;O2,sil,ph=OK;no cfc	2
51	104	1	3	4566.8	Leaking	ctd-sal=0.0012;O2,sil,ph=OK;no cfc	2
52	112	1	3	2437.5	Vent valve left open	ctd-sal=0.0021;	3
53	101	1	3	5144.9	Stopcock pushed in	ctd-sal=0.0007;O2,ph,sil=OK;no cfc	2
53	133	1	3	29.7	Did not trip properly, *		3
55	133	1	4	31.3	"Bottom open, lanyard hung up",*		4
56	116	1	3	1440.2	Leaking, *		3
56	117	1	3	1216.5	Leaking, *		3

* indicates no nutrient sample.

Stn Nbr	Samp no	Cast no	initial Fbtl nbr	Ctdprs	Problem as annotated; on deck logs	Comments	fbtlnbr re-set to:
57	104	1	3	4565.9	Leaking		3
57	116	1	3	1562.5	Leaking		3
57	133	1	4	28.4	Did not trip properly, *		4
59	103	1	3	4814.1	Leaking		3
60	128	1	3	189.2	Leaking		3
60	133	1	4	19.1	"Empty, lanyard hung up", *		4
61	127	1	3	261.3	Leaking	ctd-sal=0.0008;O2,sil=OK;no cfc,ph	2
62	201	2	3	5171	Leaking	ctd-sal=-0.0005;O2,sil=OK,no cfc,ph	2
62	204	2	4	4439.4	Stopcock pushed in	ctd-sal=0.0003;O2,sil=OK,no cfc,ph	2
63	105	1	3	3495.9	no comment	ctd-sal=0.0083;O2,cfc=high hp-high?	3
64	116	1	4	478.4	Did not trip properly, low nuts		4
64	117	1	4	365.8	"Empty, lanyard hung up", *		4
66	116	1	3	1436.3	Stopcock pushed in		3
66	126	1	3	291.2	Leaking		3
67	219	2	3	1027.4	no comment	ctd-sal=0.0056;	3
67	226	2	3	319.9	Leaking	ctd-sal=-0.0003;O2-ctd=4;ph,sil=OK	2
67	231	2	3	79	Leaking	ctd-sal=-0.011;O2,sil,ph,cfc=OK	2
68	101	1	3	5334.9	Leaking	ctd-sal=0.0003;sil,ph=OK;no cfc,O2=high	3
69	227	2	3	265.5	"Large leak, top"		4
70	116	1	3	1441.3	Minor btm leak	sal,O2,ph,sil=OK	2
71	131	1	3	79.2		sal,O2,ph,sil=OK	2
71	134	1	4	9.7	lanyard hangup		4
72	131	1	3	69.6		ctd-sal=-0.006	3
73	131	1	3	80.1		sal,O2,cfc,ph,sil=OK	2
73	134	1	3	10.1	leak bottom cap	no sal,O2,cfc,sil,ph	3
74	201	2	3	5385.3	Leaking, NO3 & sil low,	PO4 n/a=bad sal	4
77	101	1	3	5056.0		fO2=3;O2 >2% high	
77	107	1	3	3565.6		fO2=3; O2 high	
79	133	1	3	13.4	Leaking		3
80	212	2	3	1075.3	Leaking		2
80	228	2	4	119.4	Leaking, high nutrients BAD sal		4
80	229	2	4	93.6	Did not trip-no sample		4
80	230	2	4	69.1	Did not trip-no sample		4
80	231	2	4	-9	Did not trip-no sample		4
80	232	2	4	-9	Did not trip-no sample		4

* indicates no nutrient sample.

Stn Nbr	Samp no	Cast no	initial Fbtl nbr	Ctdprs	Problem as annotated; on deck logs	Comments	fbtlnbr re-set to:
80	233	2	4	-9	Did not trip-no sample		4
80	234	2	4	-9	Did not trip-no sample		4
81	104	1	3	2555.9	Leaking	sal,O2,ph,sil=OK no cfc	2
81	133	1	3	9.6	Leaking, *	no samp	3
83	103	1	3	725.5	Small leak	sal,O2,sil,ph=OK;no cfc	2
83	104	1	3	624.9	Small leak	sal,O2,sil=OK;no cfc,ph	2
83	116	1	3	130.9	Leaking	sal,O2,sil,ph=OK;no cfc	2
85	104	1	3	565.8	"Small leak, bottom cap"	sal,O2,sil,ph-OK;no cfc	2
85	121	1	3	10	"Small leak, bottom cap"	sal,O2,sil,phcfc=OK	2
87	103	1	3	1314.2	"Small leak, bottom cap"	sal,O2,ph,sil,cfc=OK	2
89	222	2	3	230.6	"Small leak, bottom cap"	sal,sil,ph=OK;O2 low,no cfc	2
90	116	1	3	590.8	Leaking	sal,O2,sil,ph=OK;no cfc	2
91	116	1	3	623.8	Small leak, bottom cap	sal:OK;O2sil,ph,cfc=OK	2
91	133	1	3	9.2	Leaking, *		3
92	222	2	3	474.9	Small leak, bottom cap	sal,O2,sil=OK;no cfc.ph	2
92	226	2	3	240.5	Small leak, bottom cap		2
92	233	2	3	20.5	Large leak, bottom cap	sal,O2=OK	2
93	133	1	3	30.1	Leaking	sal,O2,sil,cfc=OK;no ph	2
94	101	1	3	4655.3	Stopcock pushed in	sal,O2,sil=OK	2
94	119	1	4	874.6		sal=high,O2,cfc,ph=low,sil=high	4
94	121	1	3	676.8	Leaking	sal,O2,cfc,sil,ph=OK	2
95	136	1	3	2.4	Leaking, *	sal OK, no other sample data	3
97	224	2	3	525.8	Leaking	sal,O2,sil,ph=OK;no cfc	2
97	233	2	3	79.3	Leaking	sal,O2,ph,sil=OK; no cfc	2
99	116	1	3	1350.2	Small leak, bottom cap	sal,O2,sil.ph=OK;no cfc	2
99	133	1	3	79.6	Small leak, bottom cap	sal,O2,sil.ph=OK;no cfc	2
100	129	1	4	190.3	Did not trip, lanyard hung up", *		4
100	130	1	4	145.7	Did not trip, lanyard hung up", *		4
100	131	1	4	-9	"Did not trip, lanyard hung up", *		4
100	132	1	4	-9	"Did not trip, lanyard hung up", *		4
103	107	1	4	3564.9	Vent left open	sal=OK,sil=BAD	4
105	233	2	4	56.4	"Did not trip, lanyard hung up", *		4
106	124	1	3	478	Possible leak	sal,cfc,sil,ph=OK;no O2	2
106	133	1	4	69.9	Did not trip properly, *		4

* indicates no nutrient sample.

Stn Nbr	Samp no	Cast no	initial Fbtl nbr	Ctdprs	Problem as annotated; on deck logs	Comments	fbtlnbr re-set to:
107	129	1	3	190.4	Leaking	sal=ok;sil,ph,O2=OK;no cfc	2
107	130	1	3	143.9	Leaking	sal=ok;sil,ph,O2=OK;no cfc	2
107	133	1	4	69.9	Lanyard hung up		4
107	136	1	4	4.7	leaking badly		4
109	103	1	2			fO2=3; 4%higher than surrounding points	
109	111	1	3	3064.2	Leaking		3
110	216	2	3	1939.3	Leaking, *	no sal,O2,sil,ph;cfc=OK	3
110	218	2	3	1440.5	Spigot leaking	sal,O2,cfc,sil,ph=OK	2
114	111	1	3	3191	"Small leak, bottom cap	sal,O2.cfc.sil.ph+OK	2
114	124	1	3	669	Leaking	sal,O2.cfc.sil.ph+OK	2
114	136	1	4	5.3	Vent open	only sal,sil; OK	2
115	126	1	3	524.1	"Small leak, bottom cap	sal,O2,sil=OK	2
116	210	2	3	3440.6	no comment	sal,O2,=low	3
117	116	1	3	1814.5	Leaking	sal,O2,sil,ph=OK;no cfc	2
118	131	1	3	120.4	"Small leak, bottom cap	sal,O2,sil=OK	2
119	109	1	3	3561.9	"Large leak, top cap"	sal,O2,ph,sil=OK;no cfc	2
119	126	1	3	526.8	Leaking	sal,O2,sil=OK;no cfc,ph	2
119	131	1	3	163.9	"Large leak, bottom cap"		3
120	226	2	3	474.6	"Small leak, bottom cap"	sal,O2,sil,cfc=OK	2
120	231	2	3	140.1	Slight leak	sal,O2,sil,cfc,ph=OK	2
121	203	2	3	4565	Vent left open	sal,O2,sil,ph=OK;no cfc	2
121	209	2	3	3065.5	Leaked before vent open	sal,O2,sil,ph=OK;no cfc	2
121	218	2	3	1125.5	Leaking	sal,O2,sil,ph=OK;no cfc	2
123	133	1	3	80.5	Slight leak	sal,O2,sil=OK;no cfc	2
124	117					fO2=3; high	
124	124	1	3	677.8	Leaking, *	no sal,cfc,sil,ph	3
125	324	3	3	720.1	Leaking	sil,ph=OK	2
126	124	1	3	670.5	"Small leak, bottom cap"	sal,cfc,sil=OK	2
127	207	2	4	4316.1	Stopcock pushed in	sal,O2,sil=OK	2
127	209	2	3	3815.3	Leaking	sal=BAD,no cfc,ph	3
127	224	2	3	719.5	Major leaker		3
129	104					ph l0oks low ????	
129	111	1	3	3314.1	Leaking	sal,O2,sil=OK;no cfc,ph	2
130	104					phlooks low ????	
130	126	1	3	476.6	Leaking	ctd-sal=-0.007;no cfc,ph	3

* indicates no nutrient sample.

Stn Nbr	Samp no	Cast no	initial Fbtl nbr	Ctdprs	Problem as annotated; on deck logs	Comments	fbtlnbr re-set to:
131	104					ph looks low ????	
131	136	1	3	3.6	"Leaker, top cap", *	O2,ph=OK	2
132	110	1	3	3437.4	"Leaker, top cap"	sil,sal=OK	2
132	112	1	3	2939.4	"Small leak, top cap"	sil,sal=OK	2
132	131	1	3	140.7	Small leak	sal,O2,cfc,sil=OK	2
133	104	1	3	5067.6	Bottom leak	sal,O2,cfc,sil=OK	2
133	107	1	3	4314.1	Small bottom leak	sal,O2,cfc,sil=OK	2
134	224	2	3	673.6	Leaking	sal,O2,cfc,sil=OK	2
135	209	2	3	3565.1	Leaking	sal,O2,sil=OK	2
136	109	1	3	3671.3	"Leaker, top cap"	sal,O2,sil=OK	2
136	130	1	3	190.4	Small bottom leak	sal,O2,sil=OK	2
137	124	1	3	726.1	Major leak	sal,sil=OK;no cfc,O2,ph	3
137	130	1	3	217.6	"Large leak, bottom cap"	sal,sil=OK; no cfc,ph,O2	3
139	109	1	3	1814.7	Leaking	sal,O2,sil=OK;no cfc,ph	2
140	109	1	3	3439.6	"Small leak, bottom cap"	sal,O2,sil=OK;no cfc,ph	2
140	135	1	3	18.5	"Small leak, bottom cap"	sal,O2,sil=OK;no cfc,ph	2
141	102	1	3	4814.8	Small leak	sal,O2,sil=OK;no ph,cfc	2
141	103	1	3	4566.3	Small leak	sal,O2,cfc,sil=OK;no ph	2
141	109	1	3	3065.8	Small leakk	sal,O2,cfc,sil=OK;no ph	2
141	131	1	3	129.3	Leaking	sal,O2,sil=OK;no ph,cfc	2
144	125	1	3	475.7	Small leak	sal,cfc,sil=ok; no,ph.O2	2
144	133	1	3	69.8	Leaking	sal,sil=ok;O2=high?,no cfc,ph	3
146	102	1	3	4940.2	Leaking	sal,O2,cfc,sil,ph"OK	2
147	133	1	3	79.2	Leaking	sal,O2,sil=OK;no cfc,ph	2
147	135	1	3	28.4	Leaking	sal,O2,sil=OK;no cfc,ph	2
152	126	1	4	375.1	Did not trip properly, *		4
152	133	1	3	70.1	"Small leak, bottom cap"	sal,O2,sil=OK;no cfc,ph	2
152	136	1	3	4.3	Leaking	sal,O2,sil=OK;no cfc,ph	2
153	133	1	3	78.6	Leaking	sal,O2,sil=ok;no cfc,ph	2
158	111	1	3	2441.2	Stopcock pushed in	sal,O2,sil,ph=OK;no cfc	2
160	102	1	4	5247.9	Stopcock pushed in	sal,sil=OK;nocfc,O2,ph	2
160	105	1	3	4866.2	Stopcock pushed in	sal,O2,sil=OK; no cfc,ph	2
160	106	1	3	4738.1	Stopcock pushed in	sal,O2,sil=OK; no cfc,ph	2
160	128	1	4	290.7	Leaking	ctd-sal=-0.007,sil=OK;no cfc,ph,O2	4
160	136	1	4	5.1	Vent left open	sal,sil=OK,no O2,cfc,ph	2

* indicates no nutrient sample.

Stn Nbr	Samp no	Cast no	initial Fbtl nbr	Ctdprs	Problem as annotated; on deck logs	Comments	fbtlnbr re-set to:
161	106	1	3	4288.5	Stopcock pushed in	sal,O2,sil=OK;no cfc,ph	2
163	206	2	3	4564.4	Stopcock pushed in	sal,O2,sil=OK;no cfc,ph	2
163	228	2	3	324.5	Leaking from top	sal,O2,sil,ph=OK;no cfc	2
163	232	2	3	117.1	Leaking from top	sal,O2,sil,ph=OK;no cfc	2
163	234	2	3	57.9	Vent left open	sal,O2,sil,ph=OK;no cfc	2
163	235	2	3	29.6	Vent left open	sal,O2,sil,ph=OK;no cfc	2
163	236	2	3	5.3	Vent left open	sal,O2,sil,ph,cfc=OK	2
164	102	1	3	5179.4	Stopcock pushed in	sal,O2,sil=OK;no cfc,ph	2
164	136	1	3	4	Leaking	sal,sil=ok;no O2,cfc,ph	3
165	102	1	3	5599.4	Small bottom leak	sal,O2,sil=OK;no cfc,ph	2
165	106	1	3	4564.3	Stopcock pushed in	sal,O2,sil=OK;no cfc,ph	2
165	129	1	3	265.1	Stopcock pushed in		3
166	228	2	3	286.8	Stopcock pushed in	sal,O2,sil,ph=OK;no cfc	2
167	206	2	3	4566	Stopcock pushed in	sal,O2,sil=OK no cfc,ph	2
167	228	2	3	326.4	Stopcock pushed in	sal,sil=OK;no O2,cfc,ph	3
168	109	1	3	3686.8	Small bottom leak	sal,O2,sil=OK;no cfc,ph	2
168	131	1	3	140.1	Small bottom leak	sal,O2,sil=OK;no cfc,ph	2
171	112	1	3	2812.9	Stopcock pushed in	sal,O2,sil=OK;no cfc,ph	2
171	113	1	3	2562.7	Stopcock pushed in	sal,O2,sil=OK;no cfc,ph	2
171	117	1	3	1564	Small bottom leak	sal,O2,sil,ph=OK;no cfc	2
171	127	1	3	421.6	Stopcock pushed in	sal,sil=OK;no O2,cfc,ph	3
172	235	2	3	10	Small bottom leak	sal,O2,sil=OK,no cfc,ph	2
173	226	2	3	525.3	Small bottom leak	sal,O2,cfc,sil=OK;no ph	2
174	105	1	3	4689	Leaking	sal,O2,sil=OK;no cfc,ph	2
174	117	1	3	1690.4	Leaking	sal,O2,sil=OK;no cfc,ph	2
174	127	1	3	374.2	Stopcock pushed in	sal,sil=OK;no O2,cfc,ph	3
174	135	1	3	20.4	Small bottom leak	sal,O2,cfc,sil=OK;no ph	2
175	205	2	3	4899.9	Leaking from top	sal,O2,sil=OK;no cfc,ph	2
178	110	1	3	4098.9	Leaking stopcock	sal,O2,sil=OK;no cfc,ph	2
181	110	1	3	3253	Leaking, *		3

C. CTD/O_2 Techniques

ABSTRACT

Summaries of CTD/O_2 measurements and hydrographic data acquired on a Climate and Global Change cruise during the austral summer of 1996 aboard the NOAA ship Discoverer are presented. The majority of these data were collected along WOCE section P14S from 53°S, 170°E to 66°S, 171°E and WOCE section P15S from 67°S, 170°W to 0°, 169°W. Also presented are data collected along a short section across the Samoan Passage. Data acquisition and processing systems are described and calibration procedures are documented. Station location, meteorological conditions, CTD/O_2 summary data listings, profiles, and potential temperature-salinity diagrams are included for each cast. Section plots of oceanographic variables and hydrographic data listings are also given.

C.1. Introduction

(K.E. McTaggart and G.C. Johnson)

The long-term objective of the Climate and Global Change Program is to provide reliable predictions of climate change and associated regional implications on time scales ranging from seasons to centuries. In support of NOAA's Climate Program, PMEL scientists have been measuring the growing burden of greenhouse gases in the Pacific Ocean and the overlying atmosphere since 1980. The NOAA Office of Global Programs (OGP) sponsors the Ocean Tracers and Hydrography Program and Ocean-Atmosphere Carbon Exchange Study (OACES) to study ocean circulation, mixing processes, and the rate at which CO_2 and chlorofluorocarbons (CFCs) are taken up and released by the oceans. Work on this cruise was cooperative with the World Ocean Circulation Experiment (WOCE) and the Joint Global Ocean Flux Study (JGOFS). Data from this cruise will allow quantification of the zonal currents and meridional distribution of water masses throughout the full water column in the southwestern Pacific. Tracer measurements will be used to study the rates of mass formation and transport processes throughout the water column.

For all sections sampled on this cruise, stations were occupied at a nominal spacing of 30 nm, closer over steeply sloped bathymetry, and never more distant than 60 nm. Stations 1-3 were test stations occupied to evaluate the CTD/O_2 and rosette systems on the transit from Hobart, Australia to the start of P14S. These profiles were not processed and are not included in this data report. The cruise was broken up into two legs of roughly 1-month duration each by a port stop in Wellington, New Zealand after station 93. Station 94 was a reoccupation of station 93 to evaluate temporal variations that occurred during the port stop.

Full water column CTD/O_2 profiles were collected at all stations. Lowered Acoustic Doppler Current Profiler (ADCP) measurements were also collected on most casts of leg 1. In addition, underway salinity, temperature, and C02 measurements were taken along the cruise track. Shallow productivity casts were made daily, and ALACE floats were deployed during the cruise. Water samples were analyzed for a suite of natural and anthropogenic tracers including salinity, dissolved oxygen, inorganic nutrients, CFCs, carbon tetrachloride, dissolved inorganic carbon, total alkalinity, pH, PC02, dissolved organic carbon, dissolved organic nitrogen, carbon isotopes, and oxygen isotopes. Samples were collected from productivity casts for chlorophyll and primary productivity. Figure 1 shows station locations. Table 1 provides a summary of cast information.

WOCE section P 14S began with station 4 at 53°S, 170°E in 200 m of water on the south edge of the Campbell Plateau and ended with station 32 at 66°S, 171°E, intersecting the zonal WHP section S4 occupied nominally along 67°S in 1992. The section consisted of 29 stations. It sampled the entire Antarctic Circumpolar Current between the edge of the Campbell Plateau and the crest of the Pacific-Antarctic Ridge. At the ridge crest it explored a deep passage between the Ross Sea and the Southwest Pacific Basin. South of the ridge crest, it entered the north side of the Ross Sea Gyre.

WOCE section P15S began with station 33 at 67°S, 170°W, again intersecting the zonal WHP section S4 occupied nominally along 67°S in 1992. It proceeded north to station 72 at 47.5°S, 170°W, whereupon it followed a diagonal in towards the Chatham Rise until station 85 at 43.25°S, 175°E. From there it moved back away from the rise towards 170°W along a diagonal to station 104 at 36°S, 170°W. It then resumed north to station 154 at 10.5°S, 170°W, whereupon it shifted longitudes slightly to follow the axis of the Samoan Passage until station 164 at 7.5°S, 168.75°W. From there it continued north to station 174 at the equator, 168.75°W. Station 175 and 176 were added to the section to improve meridional resolution in the vicinity of the Samoan Passage. From 15°S to the equator the section overlapped WHP section P15N, occupied in 1994. The section consisted of 143 stations, discounting the duplication after the Wellington port stop. It sampled the north end of the Ross Sea Gyre, the Antarctic Circumpolar Current, the Deep Western Boundary Current system on both flanks of the Chatham Rise, the Subtropical Gyre, and the Tropical Regime up to the equator.

Stations 177 to 182 were taken after the completion of P15S but prior to the final port stop in Pago Pago, American Samoa. These profiles constitute a short, nearly zonal, section near 10°S across the Samoan Passage. These stations were taken to investigate deep water-mass and transport variability there.

C.2. Standards and Pre-Cruise Calibrations

The CTD/O_2 system is a real time data system with the data from a Sea-Bird Electronics, Inc. (SBE) 9plus underwater unit transmitted via a conducting cable to the SBE 11plus deck unit. The serial data from the underwater unit is sent to the deck unit in RS-232 NRZ format using a 34560 Hz carrier-modulated differential-phase-shift-keying (DPSK) telemetry link. The deck unit decodes the serial data and sends it to a personal computer for display and storage in a disk file using Sea-Bird SEASOFT software.

The SBE 911plus system transmits data from primary and auxiliary sensors in the form of binary number equivalents of the frequency or voltage outputs from those sensors. The calculations required to convert from raw data to engineering units of the parameters being measured are performed by software, either in real-time, or after the data has been stored in a disk file.

The SBE 911plus system is electrically and mechanically compatible with standard unmodified rosette water samplers made by General Oceanics (GO), including the 1016 36-position sampler, which was used for most stations on this cruise. An optional modem and rosette interface allows the 911plus system to control the operation of the rosette directly without interrupting the data from the CTD, eliminating the need for a rosette deck unit.

The SBE 9plus underwater unit uses Sea-Bird's standard modular temperature (SBE 3) and conductivity (SBE 4) sensors which are mounted with a single clamp and "L" bracket to the lower end cap. The conductivity cell entrance is co-planar with the tip of the temperature sensor's protective steel sheath. The pressure sensor is mounted inside the underwater unit main housing and is ported to outside pressure through the oil-filled plastic capillary tube seen protruding from the main housing bottom end cap. A compact, modular unit consisting of a centrifugal pump head and a brushless DC ball bearing motor contained in an aluminum underwater housing pump flushes water through sensor tubing at a constant rate independent of the CTD's motion. This improves dynamic performance. Motor speed and pumping rate (3000 rpm) remain nearly constant over the entire input voltage range of 12-18 volts DC.

The SBE 11plus deck unit is a rack-mountable interface which supplies DC power to the underwater unit, decodes the serial data stream, formats the data under microprocessor control, and passes the data to a companion computer. It provides access to the modem channel and control of the rosette interface. Output data is in RS-232 (serial) format.

C.2.1 Conductivity

The flow-through conductivity-sensing element is a glass tube (cell) with three platinum electrodes. The resistance measured between the center electrode and end electrode pair is determined by the cell geometry and the specific conductance of the fluid within the cell, and controls the output frequency of a Wien Bridge circuit. The sensor has a frequency output of approximately 3 to 12 kHz corresponding to conductivity from 0 to 7 S/m (0 to 70 mmho/cm). The SBE 4 has a typical accuracy/stability of +/- 0.0003 S/m/month; resolution of 0.00004 S/m at 24 samples per second; and 6800 meter anodized aluminum housing depth rating.

Pre-cruise sensor calibrations were performed at Sea-Bird Electronics, Inc. in Bellevue, Washington. The following coefficients were entered into SEASOFT using software module SEACON:

S/N 748 December 14, 1995	S/N 1561 December 14, 1995	S/N 1562 December 14, 1995
g = -4.13299236	g = -4.09205330	g = -4.16899749
h = 4.36576287e-01	h = 5.28538155e-01	h = 5.53740992e-01
i = -1.39236118e-04	i = -1.56949585e-04	i = -5.94323544e-05
j = 2.59599092e-05	j = 3.46776288e-05	j = 3.11836344e-05
ctcor = 3.2500e-06	ctcor = 3.2500e-06	ctcor = 3.2500e-06
cpcor = -9.5700e-08	cpcor = -9.5700e-08	cpcor = -9.5700e-08

Conductivity calibration certificates show an equation containing the appropriate pressure-dependent correction term to account for the effect of hydrostatic loading (pressure) on the conductivity cell:

$$C\ (\mathrm{S/m}) = (g + hf^2 + if^3 + jf^4) / [10\ (1 + cpcor\ \ p)]$$

where g, h, i, j, and m are the calibration coefficients above, f is the instrument frequency (kHz), t is the water temperature (C), and p is the water pressure (dbar). SEASOFT automatically implements this equation.

C.2.2 Temperature

The temperature-sensing element is a glass-coated thermistor bead, pressure-protected by a stainless steel tube. The sensor output frequency ranges from approximately 5 to 13 kHz corresponding to temperature from -5 to 35°C. The output frequency is inversely proportional to the square root of the thermistor resistance which controls the output of a patented Wien Bridge circuit. The thermistor resistance is exponentially related to temperature. The SBE 3 thermometer has a typical accuracy/stability of +/- 0.004°C per year; and resolution of 0.0003°C at 24 samples per second. The SBE 3 thermometer has a fast response time of 70 ms. It's anodized aluminum housing provides a depth rating of 6800 m.

Pre-cruise sensor calibrations were performed at Sea-Bird Electronics, Inc. in Bellevue, Washington. The following coefficients were entered into SEASOFT using software module SEACON:

S/N 1370 November 22, 1995	S/N 2038 December 14, 1995	S/N 2037 December 14, 1995
g = 4.84042876e-03	g = 4.11396861e-03	g = 4.13135090e-03
h = 6.74974915e-04	h = 6.20923913e-04	h = 6.33482482e-04
i = 2.38622986e-05	i = 1.98024796e-05	i = 2.11340704e-05
j = 1.66698127e-06	j = 1.99224715e-06	j = 2.16252937e-06
f0 = 1000.0	f0 = 1000.0	f0 = 1000.0

Temperature (IPTS-68) is computed according to

$$T\,(°\mathrm{C}) = 1/\,\{g+h\,[1\mathrm{n}(\,f\,0/f\,)] + i\,[1\mathrm{n}^2(\,f\,0/f\,)] + j[1\mathrm{n}^3(\,f\,0/f\,)]\} - 273.15$$

where g, h, i, j, and $f0$ are the calibration coefficients above and f is the instrument frequency (kHz). SEASOFT automatically implements this equation.

C.2.3 Pressure

The Paroscientific series 4000 Digiquartz high pressure transducer uses a quartz crystal resonator whose frequency of oscillation varies with pressure induced stress measuring changes in pressure as small as 0.01 parts per million with an absolute range of 0 to 10,000 psia (0 to 6885 dbar). Also, a quartz crystal temperature signal is used to compensate for a wide range of temperature changes. Repeatability, hysteresis, and pressure conformance are 0.005% FS. The nominal pressure frequency (0 to full scale) is 34 to 38 kHz. The nominal temperature frequency is 172 kHz + 50 ppm/°C.

Pre-cruise sensor calibrations were performed at Sea-Bird Electronics, Inc. in Bellevue, Washington. The following coefficients were entered into SEASOFT using software module SEACON:

S/N 53960 April 11, 1995	S/N 53586 October 29, 1993
c1 = -4.315048e+04	c1 = -3.920451e+04
c2 = 4.542800e-01	c2 = 6.234560e-01
c3 = 1.344380e-02	c3 = 1.350570e-02
d1 = 3.795200e-02	d1 = 3.894300e-02
d2 = 0.0	d2 = 0.0
t1 = 3.034230e+01	t1 = 3.046303e+01
t2 = -1.809380e-04	t2 = -9.018862e-05
t3 = 4.616150e-06	t3 = 4.528890e-06
t4 = 2.084220e-09	t4 = 3.309590e-09

Pressure coefficients are first formulated into

$$c = c1 + c2*U + c3*U^2$$

$$d = d1 + d2*U$$

$$t0 = t1 + t2*U + t3*U^2 + t4*U^3$$

where U is temperature in degrees Celsius. Then pressure is computed according to

$$P\,(psia) = c * [1 - (t0^2/t^2)] * \{1 - d[1 - (t0^2/*^2)]\}$$

where *t* is pressure period (µs). SEASOFT automatically implements this equation.

C.2.4 Oxygen

The SBE 13 dissolved oxygen sensor uses a Beckman polarographic element to provide in-situ measurements at depths up to 6800 meters. This auxiliary sensor is also included in the path of pumped sea water. Oxygen sensors determine the dissolved oxygen concentration by counting the number of oxygen molecules per second (flux) that diffuse through a membrane. By knowing the flux of oxygen and the geometry of the diffusion path the concentration of oxygen can be computed. The permeability of the membrane to oxygen is a function of temperature and ambient pressure. The interface electronics outputs voltages proportional to membrane current (oxygen current) and membrane temperature (oxygen temperature). Oxygen temperature is used for internal temperature compensation. Computation of dissolved oxygen in engineering units is done in the software. The range for dissolved oxygen is 0 to 650 µmol/kg; accuracy is 4 µmol/kg; resolution is 0.4 µmol/kg. Response times are 2 s at 25°C and 5 s at 0°C.

The following oxygen calibrations were entered into SEASOFT using SEACON:

S/N 130309 September 28, 1995	
m =	2.4544 e-07
b =	-4.6633 e-10
soc =	2.6721
boc =	-0.0178
tcor =	-3.3 e-02
pcor =	1.5 e-04
tau =	2.0
wt =	0.67
k =	8.9224
c =	-6.9788

The use of these constants in linear equations of the form $I = mV + b$ and $T = kV + c$ will yield sensor membrane current and temperature (with a maximum error of about 0.5°C) as a function of sensor output voltage. These scaled values of oxygen current and oxygen temperature were carried through the SEASOFT processing stream unaltered.

C.3. Data Acquisition

CTD/O_2 measurements were made using one of two Seabird 9plus CTDs each equipped with a fixed pumped temperature-conductivity (TC) sensor pair. A mobile pumped TC pair with dissolved oxygen sensor was mounted on whichever CTD was in use so that dual TC measurements and dissolved oxygen measurements were always collected. The TC pairs were monitored for calibration drift and shifts by examining the differences between the two pairs on each CTD and comparing CTD salinities with bottle salinity measurements.

PMEL's Sea-Bird 9plus CTD/O_2 S/N 09P8431-0315 (sampling rate 24 Hz) was mounted in a 36-position frame and employed as the primary package. Auxiliary sensors included a lowered ADCP, Metrox load cell, and Benthos altimeter. Water samples were collected using a General Oceanics 36-bottle rosette and 10-liter Nisken bottles. The primary package was used for the majority of 182 casts.

PMEL's Sea-Bird 9plus CTD/O_2 S/N 329053-0209 (sampling rate 24 Hz) was mounted in a 24-position frame and employed as the backup package. Auxiliary sensors included a Metrox load cell and Benthos altimeter. Water samples were collected using a Sea-Bird 24-bottle rosette, and 4-liter Niskin bottles. One test cast and 22 bad-weather stations were made using the smaller backup package.

The package entered the water from the stern of the ship and was held 5-15 m beneath the surface for one minute in order to activate the pump and attach tag lines for package recovery. Under ideal conditions the package was lowered at a rate of 30 m/min to 50 m, 45 m/min to 200 m, and 60 m/min to depth. Ship heave often caused substantial variation about these mean lowering rates, especially at southern ocean stations. Load cell values were monitored in real-time during each cast. The position of the package relative to the bottom was monitored on the ship's Precision Depth Recorder (PDR) and an altimeter. A bottom depth was estimated from bathymetric charts and the PDR ran during the bottom 1000 m of the cast. Stations were generally made to within 10 m of the bottom, sometimes farther away in heavy weather. Fig. 2 shows the depths of bottle closures during the upcast.

Upon completion of the cast, sensors were flushed with deionized water and stored with a dilute Triton-X solution in the plumbing. Niskin bottles were then sampled for various water properties detailed in the introduction. Sample protocols conformed to those specified by the WOCE Hydrographic Programme.

A Sea-Bird 11plus deck unit received the data signal from the CTD. The analog data stream was recorded onto video cassette tape as a backup. Digitized data were forwarded to a 286-AT personal computer equipped with SEASOFT acquisition and processing software version 4.216. Temperature, salinity, and oxygen profiles were displayed in real-time. Raw data files were transferred to a 486 personal computer using Laplink version 3 and backed up to optical disk.

C.3.1 Data Acquisition Problems

Some time was lost at the beginning of leg 1 owing to level-wind problems on the primary winch. The sea cable was retensioned on the drum at sea by removing the CTD/rosette package, attaching a weight to the cable, and spooling the full length of cable behind the ship while underway to within the last full wrap on the drum . Level-wind problems were much reduced after this procedure.

No useful data from the secondary TC pair and dissolved oxygen sensor was collected during station 12 owing to biological fouling of the mobile sensors. Data from the primary TC pair were processed for station 12, as well as for stations 69, 78, 79, 128, 130, 131, and 159 owing to noise. No oxygen data are available for stations 132, 133, 134, and 144 during which problems with the dissolved oxygen sensor were being diagnosed and repaired.

C.3.2 Salinity Analyses

Bottle salinity analyses were performed in the ship's salinity laboratory using two Guildline Model 8400A inductive autosalinometers standardized with IAPSO Standard Seawater batch P114. The autosalinometer in use was standardized before each run and either at the end of each run or after no more than 48 samples. The drift between standardizations was monitored and the individual samples were corrected for that drift by linear interpolation. Duplicate samples taken from the deepest bottle on each cast were analyzed on a subsequent day. Bottle salinities were compared with preliminary CTD salinities to aid in identification of leaking bottles as well as to monitor the CTD conductivity cells' performance and drift.

The expected precision of the autosalinometer with an accomplished operator is 0.001 PSS, with an accuracy of 0.003. To assess the precision of discrete salinity measurements on this cruise, a comparison was made for data from the instances in which two bottles were tripped within 10 dbar of each other at the same station below a depth of 2000 dbar. For the 124 instances in which both bottles of the pair have acceptable salinity measurements, the standard deviation of the differences is 0.0008 PSS. This value is below the expected precision.

C.4. At Sea Processing

SEASOFT consists of modular menu driven routines for acquisition, display, processing, and archiving of oceanographic data acquired with Sea-Bird equipment and is designed to work with an IBM or compatible personal computer. Raw data is acquired from the instruments and is stored as unmodified data. The conversion module DATCNV uses the instrument configuration and calibration coefficients to create a converted engineering unit data file that is operated on by all SEASOFT post processing modules. Each SEASOFT module that modifies the converted data file adds information to the header of the converted file permitting tracking of how the various oceanographic parameters were obtained. The converted data is stored in either rows and columns of ascii numbers or as a binary data stream with each value stored as a 4 byte binary floating point number. The last data column is a flag field used to mark scans as good or bad.

The following are the SEASOFT processing module sequence and specifications used in the reduction of P14S/P15S CTD/O_2 data:

DATCNV converted the raw data to pressure, temperature, conductivity, oxygen current, and oxygen temperature; and computed salinity and the time rate of change of oxygen current. DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition.

ROSSUM created a summary of the bottle data. Bottle position, date, and time were output as the first two columns. Pressure, temperature, conductivity, salinity, oxygen current, oxygen temperature, and time rate of change of oxygen current were averaged over a 2-s interval (48 scans). For the primary package, the time interval was from 5 to 3 s prior to the confirm bit in order to avoid spikes in conductivity and oxygen current owing to minor incompatibilities between the Sea-Bird 911plus CTD/O_2 system and General Oceanics 1016 rosette. Bottle data from the backup package were averaged from 1 s prior to the confirm bit to 1 s after the confirm bit in the data stream. ROSSUM computed CTD oxygen, potential temperature, and sigma-theta.

WILDEDIT marked extreme outliers in the data files. The first pass of WILDEDIT obtained an accurate estimate of the true standard deviation of the data. The data were read in blocks of 200 scans. Data greater than two standard deviations were flagged. The second pass computed a standard deviation over the same 200 scans excluding the flagged values. Values greater than 16 standard deviations were marked bad.

SPLIT removed decreasing pressure records from the data files leaving only the downcast.

FILTER performed a low pass filter on pressure with a time constant of 0.15 s. In order to produce zero phase (no time shift) the filter first runs forward through the file and then runs backwards through the file.

ALIGNCTD aligned conductivity in time relative to pressure to ensure that all calculations were made using measurements from the same parcel of water.

- Conductivity for the primary sensor on the 36-bottle package was advanced by -0.020 s.
- Conductivity for the primary sensor on the 24-bottle package was advanced by -0.010 s.
- Conductivity for the secondary, mobile sensor on either package was advanced 0.055 s.

CELLTM used a recursive filter to remove conductivity cell thermal mass effects from the measured conductivity. For C748 with an epoxy coating, the thermal anomaly amplitude (alpha=0.03) and the time constant (1/beta=9.0) were higher than for C1561 and C1562 with no coating (alpha=0.02, 1/beta=7.0).

DERIVE was used to compute fall rate (m/s) with a time window size for fall rate and acceleration of 2.0 seconds.

LOOPEDIT marked scans where the CTD was moving less than the minimum velocity of 0.25 m/s or travelling backwards due to ship roll.

BINAVG averaged the data into 1-dbar pressure bins starting at 1 dbar with no surface bin. The center value of the first bin was set equal to the bin size. The bin minimum and maximum values are the center value +/- half the bin size. Scans with pressures greater than the minimum and less than or equal to the maximum were averaged. Scans were interpolated so that a data record exists every decibar.

STRIP removed scan number and fall rate from the data files.

TRANS converted the data file format from binary to ascii.

C.5. Post-Cruise Calibrations

Post-cruise sensor calibrations were done at Sea-Bird Electronics, Inc. during May 1996. Mobile, secondary sensor pair T1370 and C748 were selected for final data reduction for all stations except 12, 69, 128, 130, 131, and 159. Post-cruise calibrations showed T1370 to have drifted by 0.43e-03°C over the 3.2 months between calibrations. Station 12 data are from sensors T2037 and C1562. Post-cruise calibrations showed T2037 to have drifted by -0.28e-03°C over the 3.2 months between calibrations. The remaining station data are from sensors T2038 and C1561. Post-cruise calibrations showed T2038 to have drifted by 0.11e-03°C over the 3.3 months between calibrations.

C.5.1 Conductivity

SEASOFT module ALIGNCTD was used to align conductivity measurements in time relative to pressure. Measurements can be mis-aligned due to the inherent time delay of the sensor response, the water transit time delay in the pumped plumbing line, and the sensors being physically mis-aligned in depth. Because SBE 3 temperature response is fast (0.06 s), it is not necessary to advance temperature relative to pressure. When measurements are properly aligned, salinity spiking and density errors are minimized.

For a SBE 9 CTD with ducted TC sensors and a 3000 rpm pump the typical net advance of conductivity relative to temperature is 0.073 s. The SBE 11 deck units advanced primary conductivity 0.073 s but do not advance secondary conductivity. Therefore the alignment of C748 conductivity data, which was from the secondary sensor channel (except for stations 78 and 79), was much larger, typically 0.06 s versus coming from a primary sensor channel, typically 0.02 s.

Conductivity slope and bias, along with a linear pressure term (modified beta), were computed by a least-squares minimization of CTD and bottle conductivity differences. The function minimized was

$$\mathrm{BC} - m * \mathrm{CC} - b - \mathrm{beta} * \mathrm{CP}$$

where BC is bottle conductivity (S/m), CC is pre-cruise calibrated CTD conductivity (S/m), CP is the CTD pressure (dbar), m is the conductivity slope, b is the bias (S/m), and beta is a linear pressure term (S/m/dbar). The final CTD conductivity (S/m) is

$$m * \mathrm{CC} + b + \mathrm{beta} * \mathrm{CP}$$

The slope term m is a fourth-order polynomial function of station number to allow the entire cruise to be fit at once with a smoothly-varying station- dependent slope correction. For sensors C748 and C1561 a series of fits were made, each fit throwing out bottle values for locations having a residual between CTD and bottle conductivities greater than three standard deviations. This procedure was repeated with the remaining bottle values until no more bottle values were thrown out.

For C748, the slope correction ranged from 1.0000501 to 1.0001274, the bias applied was -7.5e-04, and the beta term was -9.01e-09. Of 5680 bottles, the percentage of bottles retained in the fit was 85.2 with a standard deviation of CTD versus bottle conductivity differences of 9.88e-05 S/m. For C1561, the slope correction ranged from 1.0001481 to 1.0002849, the bias applied was -3.8e-

04, and the beta term was -3.16e-09. Of 5118 bottles, the percentage of bottles retained in the fit was 88.1 with a standard deviation of 9.93e-05 S/m.

For station 12, station 13 calibrated secondary salinity data was used as a reference. A slope, bias, and pressure correction was determined that matched station 13 uncalibrated primary salinity (C1562,T2037) to station 13 calibrated secondary salinity (C748,T1370). These coefficients (slope=1.004, bias=-0.0011, beta=-2.49e-08) were used to calibrate station 12 primary salinity (C1562,T2037).

CTD-bottle conductivity are plotted against cast number to show the stability of the calibrated CTD conductivities relative to the bottle conductivities (McTaggart and Johnson, 1997; Fig. 3, upper panel). CTD-bottle conductivity differences are plotted against pressure to show the tight fit below 800 m and the increasing scatter above 800 m (McTaggart and Johnson, 1997; Fig. 3, lower panel).

C.5.2 Temperature

Adjustments were made to the bias of the thermistors as deviations from the pre-cruise calibrations on a station by station basis. These deviations were obtained from a linear fit of the pre-cruise and post-cruise temperature residuals from the pre-cruise calibration versus time.

A pressure correction was then applied to each sensor such that

$$CT = CT * pcor * CP$$

where CT is CTD temperature (C) with the bias adjustment, pcor is the pressure correction (dbar) for each sensor, and CP is CTD pressure (dbar).

$$pcor1370 = -2.6e-03/9000 = -2.8889e-007$$

$$pcor2037 = -2.3e-03/9000 = -2.5556e-007$$

$$pcor2038 = -1.7e-03/9000 = -1.8889e-007$$

Also, a uniform correction is applied for heating of the thermistor owing to viscous effects. All the thermistors are biased high by this effect and were adjusted down accordingly. An adjustment of 0.6e-03°C results in errors of no more than +-0.15°C from this effect for the full range of oceanographic temperature and salinity.

Post-cruise temperature and conductivity calibrations were applied to all sensor pairs using PMEL program CALCTD (STA12CAL for station 12). Surface values were filled using PMEL program FILLSFC. FILLSFC copied the first good value of salinity and potential temperature back to the surface and then back- calculated temperature and conductivity. Primary and secondary sensor differences were examined. Data from the secondary sensor pair (T1370/C748) was chosen for all stations except 12, 69, 78, 79, 128, 130, 131, and 159. Primary sensor data chosen for these 8 stations were within .001 psu of the secondary sensor data of the surrounding stations. All profiles were despiked and data linearly interpolated using PMEL program DESPIKE.

Package slowdowns and reversals owing to ships heave can move mixed water in tow to in front of the CTD sensors and obscure measurements. In addition to SEASOFT module LOOPEDIT (see below), PMEL program DELOOP computed values of density locally referenced between every 1 dbar of pressure to compute $N^2 = (-g/\text{rho})(d\text{rho}/dz)$ and linearly interpolated over those records where $N^2 <= -1.0e\text{-}05\ s^{-2}$.

Post-cruise calibrations were applied to CTD data associated with bottle data using PMEL program CALMSTR. CALMSTR also amended WOCE quality flags associated with CTD and bottle salinities. Eighteen CTD salinities were flagged as bad during station 78 likely owing to clogged plumbing of the primary sensors during the up-cast. Of the 5640 bottle salinities, 0.33% were flagged as bad and 2.68% were flagged as questionable.

C.5.3 Oxygen

In situ oxygen samples collected during CTD profiles are used for post-measurement calibration. Calibrated CTD data associated with bottle data were merged with bottle oxygen data flagged as 'good'. Because the dissolved oxygen sensor has an obvious hysteresis, program OXDWNP replaced up-profile water sample data with corresponding down-profile CTD/O_2 data at common pressure levels. The time rate of change of oxygen current was computed using 2 second intervals in SEASOFT and smoothed using a median filter of width 5 dbar prior to OXDWNP. Oxygen saturation values were computed according to Benson and Krause (1984) in units of µmol/kg.

The algorithm used for converting oxygen sensor current and probe temperature measurements to oxygen as described by Owens and Millard (1985) requires a non-linear least squares regression technique in order to determine the best fit coefficients of the model for oxygen sensor behavior to the water sample observations. WHOI program OXFITMR uses Numerical Recipes (Press et al., 1986) Fortran routines MRQMIN, MRQCOF, GAUSSJ, and COVSRT to perform non-linear least squares regression using Levenberg-Marquardt method. A Fortran subroutine FOXY describes the oxygen model with the derivatives of the model with respect to six coefficients in the following order: oxygen current slope, temperature correction, pressure correction, weight, oxygen current bias, and oxygen current lag.

Program OXFITMR reads the data for a group of stations. The data are edited to remove spurious points where values are less than zero or greater than 1.2 times the saturation value. The routine varies the six (or fewer) parameters of the model in such a way as to produce the minimum sum of squares in the difference between the calibration oxygens and the computed values. Individual differences between the calibration oxygens and the computed oxygen values (residuals) are then compared with the standard deviation of the residuals. Any residual exceeding an edit factor of 2.8 standard deviations is rejected. A factor of 2.8 will have a 0.5% chance of rejecting a valid oxygen value for a normally distributed set of residuals. The iterative fitting process is continued until none of the data fail the edit criteria. The best fit to the oxygen probe model coefficients is then determined. Coefficients were applied by PMEL program CALOX2W and CTD oxygen was computed using subroutine OXY6W.

By plotting the oxygen residuals versus station, appropriate station groupings for further refinements of fitting were obtained by looking for abrupt station to station changes in the residuals. For each grouping, two sets of coefficients were determined, one fitting all the bottles and a second fitting only bottles deeper than just above the median bottle oxygen minimum. Sometimes it was necessary to fix values of some oxygen algorithm parameters to keep those parameters within a reasonable range (noted by asterisks in Table 2). Final coefficients were applied to downcast data using PMEL program OXYCALC; and to bottle data using OXYCALB. The two sets of coefficients were blended at the oxygen minimum using a set of hyperbolic tangent functions with 250-dbar decay scales.

CTD oxygen values were despiked using PMEL program CLEANOX. Bad CTD oxygen data were flagged for all of station 12 owing to clogged plumbing, parts of stations 127-131 where the dissolved oxygen module failed in the deep water (the dissolved oxygen module was replaced prior to station 135), and stations 177-182 above 2850 dbar where no shallow bottle data were available to calibrate the sensor.

CTD-bottle oxygen differences are plotted against station number to show the stability of the calibrated CTD oxygens relative to the bottle oxygens (McTaggart and Johnson, 1997; Fig. 4, upper panel). CTD-bottle oxygen differences are plotted against pressure to show the tight fit below 1200 m and the increasing scatter above 1200 m (McTaggart and Johnson, 1997; Fig. 4, lower panel).

PMEL program P15_EPIC converted finalized CTD data files into EPIC format (Soreide, 1995); and computed ITS-90 temperature, ITS-90 potential temperature, and dynamic height. EPIC data files contain a WOCE quality flag parameter associated with pressure, temperature, salinity, and CTD oxygen. Quality flag definitions can be found in the WOCE Operations Manual (1994).

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Table 1. CTD Cast Summary.

STN	LATITUDE	LONGITUDE	DATE	TIME T	W/D (kts)	W/S (m)	DEPTH† (m)	HAB* (db)	CAST
4	53 0.1S	169 59.3E	9 JAN 96	13	270	5	195	12	185
5	53 29.9S	170 29.6E	9 JAN 96	342	275	8	732	10	733
6	53 59.9S	171 0.1E	9 JAN 96	736	275	10	1159	10	1172
7	54 10.2S	171 10.9E	9 JAN 96	1022	320	9	1346	10	1368
8	54 19.8S	171 20.2E	9 JAN 96	1338	315	15	2583	11	2582
9	54 30.3S	171 29.8E	9 JAN 96	1852	355	16	4373	9	4503
10	54 59.7S	172 0.7E	10 JAN 96	203	260	19	5350	5	5469
11	55 30.4S	172 27.0E	10 JAN 96	904	250	38		10	5453
12	55 59.8S	173 0.6E	10 JAN 96	1750	240	27	5448	10	5544
13	56 29.2S	173 30.2E	11 JAN 96	42	220	20	5350	0	5466
14	56 59.7S	173 58.6E	11 JAN 96	908	230	17	5437	10	5549
15	57 30.3S	173 58.5E	11 JAN 96	1731	275	23	5368	11	5425
16	58 0.2S	173 59.5E	12 JAN 96	1	300	18	5206	16	5308
17	58 30.3S	173 58.2E	12 JAN 96	641	315	21	5043	5	5108
18	58 59.8S	174 0.0E	13 JAN 96	1344	265	25	5109	8	5216
19	59 28.7S	173 59.7E	13 JAN 96	2208	280	30	4998	18	5077
20	59 57.9S	173 57.9E	13 JAN 96	530	270	34		40	4419
21	60 30.3S	173 57.8E	13 JAN 96	1958	285	25	5016	22	5107
22	60 59.1S	173 58.8E	14 JAN 96	257	315	19	4692	9	4774
23	61 30.0S	174 0.2E	14 JAN 96	856	340	27	5025	10	5134
24	62 0.0S	173 16.1E	14 JAN 96	1631	330	23	4450	10	4538
25	62 26.9S	172 35.2E	14 JAN 96	2249	305	26	4414	12	4499
26	62 44.7S	172 9.0E	15 JAN 96	424	270	30	4425	39	4052
27	63 0.0S	171 44.9E	15 JAN 96	1135	295	23		10	2644
28	63 30.1S	170 59.6E	15 JAN 96	1744	5	16	2374	12	2391
29	63 59.8S	171 6.6E	16 JAN 96	29	10	26	2551	25	2534
30	64 40.6S	170 58.6E	16 JAN 96	737	330	24	3430	10	3457
31	65 20.2S	171 0.0E	16 JAN 96	1459	35	14	3403	6	3461
32	66 0.9S	171 1.6E	17 JAN 96	11	355	12	3103	7	3159
33	66 59.6S	170 0.0W	18 JAN 96	1150	340	18	3587	10	3668
34	66 20.3S	170 0.0W	18 JAN 96	1930	325	12	3384	10	3431
35	65 39.8S	170 0.3W	19 JAN 96	114	305	17	3142	7	3190
36	64 59.6S	170 0.9W	19 JAN 96	815	265	23		6	2905
37	64 30.1S	169 59.9W	19 JAN 96	1333	230	32	2332	11	2357
38	63 59.7S	170 2.0W	19 JAN 96	1858	240	28	2744	19	2922
39	63 30.1S	170 0.3W	20 JAN 96	57	280	23	2766	12	2842
40	62 59.7S	170 1.4W	20 JAN 96	630	255	17	3046	12	3064
41	62 30.0S	169 59.8W	20 JAN 96	1206	310	15		17	2473
42	62 0.2S	169 59.9W	20 JAN 96	1806	330	28	3384	11	3431
43	61 29.5S	170 0.0W	21 JAN 96	37	315	33	3463	12	3434
44	61 0.1S	170 0.3W	21 JAN 96	2105	300	15	4169	30	4190
45	60 29.7S	169 59.6W	22 JAN 96	410	280	34	3926	10	4013
46	60 0.3S	170 0.3W	22 JAN 96	1030	310	17	3702	12	3747
47	59 30.2S	169 59.9W	22 JAN 96	1702	315	20	4007	10	4104
48	58 59.9S	170 0.2W	22 JAN 96	2311	310	18	4771	10	4860
49	58 29.6S	170 0.8W	23 JAN 96	547	315	17	5188	10	5295
50	57 59.7S	170 0.8W	23 JAN 96	1212	290	13	4119	8	4492
51	57 30.1S	170 0.4W	23 JAN 96	1858	240	9	4998	7	5110
52	57 0.2S	170 0.2W	24 JAN 96	122	250	14	5165	8	5261
53	56 29S	169 59.8W	24 JAN 96	751	250	21	5052	9	5159
54	56 0.0S	170 1.8W	24 JAN 96	1352	220	20	5157	7	5236

STN	LATITUDE	LONGITUDE	DATE	TIME T	W/D (kts)	W/S (m)	DEPTH† (m)	HAB* (db)	CAST
55	55 29.9S	170 0.0W	24 JAN 96	2050	240	5	4945	9	5049
56	54 59.8S	170 0.0W	25 JAN 96	307	285	11	4812	7	4916
57	54 29S	170 0.1W	25 JAN 96	900	285	13	4811	3	4929
58	54 0.1S	169 59.3W	25 JAN 96	1545	290	16	5009	8	5138
59	53 39S	169 59.4W	25 JAN 96	2122	270	17	5131	5	5253
60	53 19.9S	169 59.6W	26 JAN 96	320	280	22	5286	8	5459
61	53 0.0S	170 0.5W	26 JAN 96	925	275	22	5193	9	5298
62	52 29.9S	170 1.8W	26 JAN 96	1643	270	27	5070	7	5173
63	52 0.1S	170 7.8W	26 JAN 96	2325	275	26	4970	10	5067
64	51 30.0S	170 0.2W	27 JAN 96	606	270	26	4754	20	4876
65	51 0.2S	170 0.4W	27 JAN 96	1221	250	20	5249	12	5321
66	50 29S	169 59.6W	27 JAN 96	1937	220	10	5052	15	5129
67	50 0S	169 59.4W	28 JAN 96	225	210	11	5361	8	5479
68	49 30.3S	170 0.9W	28 JAN 96	917	265	15	5217	15	5337
69	48 59.6S	169 59.4W	28 JAN 96	1633	270	18	5253	10	5340
70	48 30.0S	170 0.2W	28 JAN 96	2248	310	10	5303	5	5409
71	47 59.8S	170 0.3W	29 JAN 96	531	340	10	5293	10	5400
72	47 30.3S	169 59.8W	29 JAN 96	1148	45	13	5309	5	5474
73	47 6.5S	170 27.7W	29 JAN 96	1902	70	6	5391	8	5500
74	46 43S	170 54.7W	30 JAN 96	124	45	6	5292	9	5387
75	46 20.0S	171 22.2W	30 JAN 96	743	50	10	5101	8	5196
76	45 57.0S	171 49.5W	30 JAN 96	1446	100	15	5156	9	5250
77	45 33.6S	172 16.7W	30 JAN 96	2127	110	9	4968	7	5057
78	45 10.6S	172 44.2W	31 JAN 96	443	180	10	4660	10	4738
79	44 50.1S	173 8.2W	31 JAN 96	1035	230	15	3832	10	3869
80	44 31.8S	173 29.4W	31 JAN 96	1707	230	16	3397	10	3452
81	44 19.2S	173 44.7W	31 JAN 96	2119	225	10	3077	9	3115
82	44 9S	173 56.3W	I FEB 96	106	280	5	1897	10	1911
83	43 50S	174 17.7W	1 FEB 96	434	250	11	946	10	959
84	43 38.8S	174 32.2W	1 FEB 96	710	0	0	790	10	789
85	43 15.2S	174 59.9W	1 FEB 96	1023	280	9	788	12	785
86	42 55S	174 47.2W	1 FEB 96	1328	270	5	1054	10	1055
87	42 44.8S	174 39.3W	1 FEB 96	1627	300	4	1581	9	1595
88	42 24.1S	174 24.4W	1 FEB 96	2014	315	7	2654	10	2677
89	42 10.1S	174 15.0W	2 FEB 96	6	350	10	2862	7	2889
90	41 42.8S	173 56.5W	2 FEB 96	520	330	12	3118	6	3162
91	41 16.0S	173 38.7W	2 FEB 96	1014	325	12	3319	6	3353
92	40 49.5S	173 19.5W	2 FEB 96	1545	330	14	4169	6	4239
93	40 23.6S	173 2.0W	2 FEB 96	2056	345	18	4574	9	4652
94	40 23.5S	173 1.7W	13 FEB 96	2049	130	15	4574	4	4658
95	39 57.7S	172 42.2W	14 FEB 96	326	150	22	4738	8	4823
96	39 31-0S	172 25.2W	14 FEB 96	937	190	23	4761	8	4848
97	39 4.3S	172 7.7W	14 FEB 96	1612	160	18	4835	10	4929
98	38 37.8S	171 48.6W	14 FEB 96	2202	140	12	4914	10	5003
99	38 11S	171 30.2W	15 FEB 96	423	140	8	4932	10	5031
100	37 45.8S	171 12.0W	15 FEB 96	1033	130	14	4997	7	5119
101	37 18.6S	170 53.7W	15 FEB 96	1727	145	14	5130	5	5230
102	36 52.3S	170 37.0W	15 FEB 96	2306	210	12	5278	6	5384
103	36 27.0S	170 17.2W	16 FEB 96	513	220	15	5122	8	5219
104	36 0.2S	170 0.3W	16 FEB 96	1135	200	19	5069	8	5156
105	35 40.3S	170 0.9W	16 FEB 96	1727	205	24	4292	5	4329
106	35 20.0S	170 0.1W	16 FEB 96	2233	170	21	4895	7	4981
107	35 0.5S	169 59.6W	17 FEB 96	415	140	19	5250	5	5348
108	34 30.3S	170 0.2W	17 FEB 96	1137	160	20	5487	6	5591

STN	LATITUDE	LONGITUDE	DATE	TIME T	W/D (kts)	W/S (m)	DEPTH† (m)	HAB* (db)	CAST
109	33 59.8S	170 0.0W	17 FEB 96	1849	150	16	5533	6	5640
110	33 29.9S	170 0.1W	18 FEB 96	119	150	10	5416	6	5509
111	33 0.1S	170 0.1W	18 FEB 96	736	115	10	5582	10	5677
112	32 30.1S	170 0.1W	18 FEB 96	1404	115	8	5533	7	5651
113	31 59.8S	169 59.8W	18 FEB 96	2055	140	6	5677	7	5790
114	31 30.0S	169 59.3W	19 FEB 96	330	90	7	5526	8	5645
115	31 0S	169 59.7W	19 FEB 96	951	80	15	5606	7	5725
116	30 30.3S	169 59.8W	19 FEB 96	1640	90	14	5537	9	5640
117	30 0.2S	169 59.8W	19 FEB 96	2259	80	12	5413	7	5514
118	29 30.2S	169 59.8W	20 FEB 96	503	90	15	5148	12	5190
119	29 0.8S	169 59.9W	20 FEB 96	1113	70	18	5596	15	5684
120	28 30.5S	169 59.8W	20 FEB 96	1809	90	10	5459	9	5555
121	28 0.3S	169 59.6W	21 FEB 96	10	90	13	4907	10	4966
122	27 30.1S	170 0.1W	21 FEB 96	600	100	20	5349	7	5485
123	27 0.3S	169 59.5W	21 FEB 96	1202	95	13	5241	7	5331
124	26 29.7S	169 59.4W	21 FEB 96	1906	110	24	5613	8	5710
125	26 0.3S	169 59.7W	22 FEB 96	321	100	20	5601	9	5695
126	25 30.0S	170 0.0W	22 FEB 96	1005	105	17	5833	9	5944
127	25 0.1S	169 59.9W	22 FEB 96	1734	100	20	5640	3	5818
128	24 30.0S	170 0.1W	23 FEB 96	16	90	16	5650	10	5757
129	23 59.8S	170 0.1W	23 FEB 96	720	80	16	5678	10	5780
130	23 30.1S	170 0.1W	23 FEB 96	1404	100	18	5666	7	5781
131	22 59.8S	169 59.7W	23 FEB 96	2139	120	9	5691	9	5799
132	22 30.0S	169 59.9W	24 FEB 96	448	120	13	5649	7	5752
133	22 0.0S	169 59.9W	24 FEB 96	1127	160	12	5626	8	5731
134	21 30S	170 0.1W	24 FEB 96	1837	150	7	5421	6	5514
135	20 59.7S	169 59.6W	25 FEB 96	107	160	5	5461	4	5566
136	20 29S	170 0.1W	25 FEB 96	739	175	5	5598	40	5722
137	20 0.0S	170 0.1W	25 FEB 96	1354	170	6	5315	7	5429
138	19 29.9S	170 0.1W	25 FEB 96	2023	80	4	4904	8	4982
139	19 0.1S	170 3.4W	26 FEB 96	159	350	5	2991	10	3047
140	18 30.3S	170 0.1W	26 FEB 96	730	330	9	5260	3	5343
141	18 0.0S	170 0.0W	26 FEB 96	1324	350	3	4912	9	4991
142	17 30.1S	170 0.0W	26 FEB 96	1948	65	5	5024	8	5097
143	17 0.1S	169 59.8W	27 FEB 96	156	80	12	4974	7	5081
144	16 30.3S	169 59.9W	27 FEB 96	746	80	17	5134	6	5208
145	16 0.2S	169 59.9W	27 FEB 96	1343	90	13	5145	5	5233
146	15 29.8S	170 0.1W	27 FEB 96	2028	70	10	5087	8	5172
147	15 0.2S	170 0.0W	28 FEB 96	250	0	10	4820	8	4884
148	14 40.0S	169 59.9W	28 FEB 96	800	80	14	3315	8	3365
149	14 16.9S	169 59.8W	28 FEB 96	1225	20	10	3535	8	3578
150	13 58.3S	170 0.0W	28 FEB 96	1648	355	11	2938	9	2986
151	13 49.1S	170 0.1W	28 FEB 96	2111	40	7	4303	7	4367
152	13 30.1S	170 0.0W	29 FEB 96	231	280	6	4878	8	4952
153	12 59S	170 0.0W	29 FEB 96	821	95	11	4969	10	5047
154	12 29.9S	169 59.9W	29 FEB 96	1403	20	7	5000	5	5084
155	12 0.1S	170 0.1W	29 FEB 96	2018	310	11	5078	9	5016
156	11 30.0S	170 0.0W	1 MAR 96	217	330	13	5057	9	5138
157	11 0.1S	170 0.0W	1 MAR 96	807	20	9	5124	10	5205
158	10 30.1S	169 59.8W	1 MAR 96	1345	350	7	4876	5	4964
159	9 55.5S	169 37.7W	1 MAR 96	2112	20	20	5205	10	5285
160	9 30.1S	168 59.4W	2 MAR 96	429	60	18	5340	5	5432
161	9 0.0S	168 52.6W	2 MAR 96	1036	70	19	4866	9	4973
162	8 29S	168 44.9W	2 MAR 96	1726	40	10	5154	6	5243

STN	LATITUDE	LONGITUDE	DATE	TIME T	W/D (kts)	W/S (m)	DEPTH† (m)	HAB* (db)	CAST
163	8 0.0S	168 37.0W	2 MAR 96	2343	40	5	5164	8	5260
164	7 30.0S	168 45.0W	3 MAR 96	542	70	10	5273	7	5364
165	7 0.0S	168 44.9W	3 MAR 96	1141	100	10	5670	8	5767
166	6 30.1S	168 44.9W	3 MAR 96	1854	70	10	5535	10	5646
167	6 0.0S	168 45.0W	4 MAR 96	123	30	10	5671	8	5769
168	5 30.1S	168 45.0W	4 MAR 96	803	50	10	5379	8	5522
169	5 0.0S	168 45.0W	4 MAR 96	1441	50	9	5572	10	5666
170	4 0.0S	168 45.1W	4 MAR 96	2242	40	14	5208	8	5290
171	3 0S	168 45.0W	5 MAR 96	712	30	20	5379	4	5467
172	2 0S	168 45.0W	5 MAR 96	1555	40	17	3285	10	3447
173	1 0S	168 45.2W	6 MAR 96	12	80	17	5786	8	5891
174	0 0.1S	168 45.0W	6 MAR 96	828	70	16	5581	10	5683
175	7 44.8S	168 40.2W	8 MAR 96	14	80	14	5319	3	5414
176	8 15.1S	168 41.3W	8 MAR 96	549	75	10	4964	6	5051
177	10 8.7S	168 58.8W	8 MAR 96	1642	100	12	4640	8	4709
178	10 4.1S	169 12.7W	8 MAR 96	2108	100	10	5254	10	5336
179	9 55.2S	169 37.7W	9 MAR 96	248	70	11	5215	4	5306
180	9 47.0S	170 3.5W	9 MAR 96	1024	95	7	5014	8	5097
181	9 41.6S	170 19.5W	9 MAR 96	1459	30	6	4293	8	4372
182	9 35.7S	170 36.1W	9 MAR 96	1900	90	9	4038	7	4090

* height above bottom depth
† corrected water depth

Table 2a: Full water column station groupings for CTD oxygen algorithm parameters.

Station	StdDev	#Obs	2.8*sd	1:Bias	2:Slope	3:Pcor	4:Tcor	5:Wt	6:Lag
4-9	0.1351E+01	96	3.782	0.014	0.3616E-02	0.1350E-03*	-0.3149E-01	0.8702E+00*	0.3275E+01*
10-13	0.1732E+01	73	4.849	0.026	0.3561E-02	0.1350E-03*	-0.3003E-01	0.8702E+00*	0.3275E+01*
14-18	0.9219E+00	145	2.581	0.007	0.3815E-02	0.1350E-03*	-0.3797E-01	0.8702E+00*	0.3275E+01*
19-24	0.1207E+01	108	3.380	0.020	0.3702E-02	0.1350E-03*	-0.3494E-01	0.8702E+00*	0.3275E+01*
25-31	0.8802E+00	149	2.465	0.019	0.3738E-02	0.1350E-03*	-0.3822E-01	0.8702E+00*	0.3275E+01*
32-45	0.1088E+01	322	3.045	0.017	0.3772E-02	0.1338E-03	-0.3540E-01	0.6807E+00	0.7588E+01
46-53	0.9705E+00	237	2.718	0.023	0.3676E-02	0.1345E-03	-0.3174E-01	0.6084E+00	0.6309E+01
54-62	0.1516E+01	273	4.244	0.021	0.3675E-02	0.1361E-03	-0.3032E-01	0.8185E+00	0.1341E+01
63-77	0.2001E+01	430	5.603	0.045	0.3481E-02	0.1310E-03	-0.2757E-01	0.8358E+00	0.2439E+01
78-87	0.2184E+01	231	6.114	0.044	0.3320E-02	0.1449E-03	-0.2536E-01	0.7788E+00	0.2021E+01
88-95	0.1724E+01	255	4.827	0.050	0.3271E-02	0.1409E-03	-0.2511E-01	0.7474E+00	0.2745E+01
96-113	0.1770E+01	574	4.956	0.034	0.3472E-02	0.1389E-03	-0.2739E-01	0.8249E+00	0.2537E+01
114-131	0.1687E+01	587	4.724	0.034	0.3479E-02	0.1390E-03	-0.2703E-01	0.8737E+00	0.3543E+01
135-154	0.1714E+01	624	4.800	0.045	0.2938E-02	0.1476E-03	-0.2465E-01	0.8803E+00	0.5267E-01
155-171	0.1929E+01	558	5.402	0.009	0.3289E-02	0.1508E-03	-0.2794E-01	0.8965E+00	0.1374E-01
172-176	0.1494E+01	124	4.182	-0.006	0.3554E-02	0.1474E-03	-0.3070E-01	0.7925E+00	0.0000E+00*
177	0.4873E+00	13	1.364	0.021	0.3213E-02	0.1474E-03*	-0.4386E-01	0.7925E+00*	0.0000E+00*
178	0.8195E+00	16	2.295	-0.009	0.3443E-02	0.1474E-03*	-0.8431E-01	0.7925E+00*	0.0000E+00*
179	0.5936E+00	15	1.662	-0.019	0.3316E-02	0.1474E-03*	-0.9472E-01	0.7925E+00*	0.0000E+00*
180	0.5059E+00	13	1.416	-0.040	0.3283E-02	0.1474E-03*	-0.1163E+00	0.7925E+00*	0.0000E+00*
181	0.3037E+00	10	0.850	-0.041	0.3268E-02	0.1474E-03*	-0.1508E+00	0.7925E+00*	0.0000E+00*
182	0.1928E+01	7	5.398	-0.098	0.3711E-02	0.1474E-03*	-0.1875E+00	0.7925E+00*	0.0000E+00*

fixed parameter

Table 2b: Deep water column station groupings for CTD oxygen algorithm parameters.

Station	StdDev	#Obs	2.8*,sd	1:Bias	2:Slope	3:Pcor	4:Tcor	5:Wt	6:Lag
10-18	0.8233E+00	119	2.305	0.000	0.3918E-02	0.1350E-03*	-0.4539E-01	0.8702E+00*	0.3275E+01*
19-31	0.8240E+00	187	2.307	0.016	0.3754E-02	0.1350E-03*	-0.3740E-01	0.8702E+00*	0.3275E+01*
32-45	0.8000E+00	237	2.240	0.021	0.3735E-02	0.1338E-03*	-0.3460E-01	0.6807E+00*	0.7588E+01*
46-53	0.5762E+00	131	1.613	0.010	0.3846E-02	0.1345E-03*	-0.3893E-01	0.6084E+00*	0.6309E+01*
54-62	0.4671E+00	139	1.308	-0.001	0.3939E-02	0.1361E-03*	-0.3908E-01	0.8185E+00*	0.1341E+01*
63-77	0.5677E+00	190	1.590	0.008	0.3972E-02	0.1310E-03*	-0.4515E-01	0.8358E+00*	0.2439E+01*
78-95	0.8477E+00	90	2.374	-0.011	0.3991E-02	0.1409E-03*	-0.3776E-01	0.7474E+00*	0.2745E+01*
96-113	0.7719E+00	196	2.161	-0.001	0.3901E-02	0.1389E-03*	-0.3079E-01	0.8249E+00*	0.2537E+01*
114-131	0.7562E+00	213	2.117	-0.008	0.4008E-02	0.1390E-03*	-0.3101E-01	0.8737E+00*	0.3543E+01*
135-154	0.8193E+00	180	2.294	-0.003	0.3476E-02	0.1476E-03*	-0.2547E-01	0.8803E+00*	0.5267E-01*
155-171	0.8459E+00	225	2.368	-0.013	0.3480E-02	0.1508E-03*	-0.6254E-02	0.8965E+00*	0.1374E-01*
172-176	0.1120E+01	64	3.135	-0.009	0.3524E-02	0.1474E-03*	-0.1246E-01	0.7500E+00*	0.0000E+00*

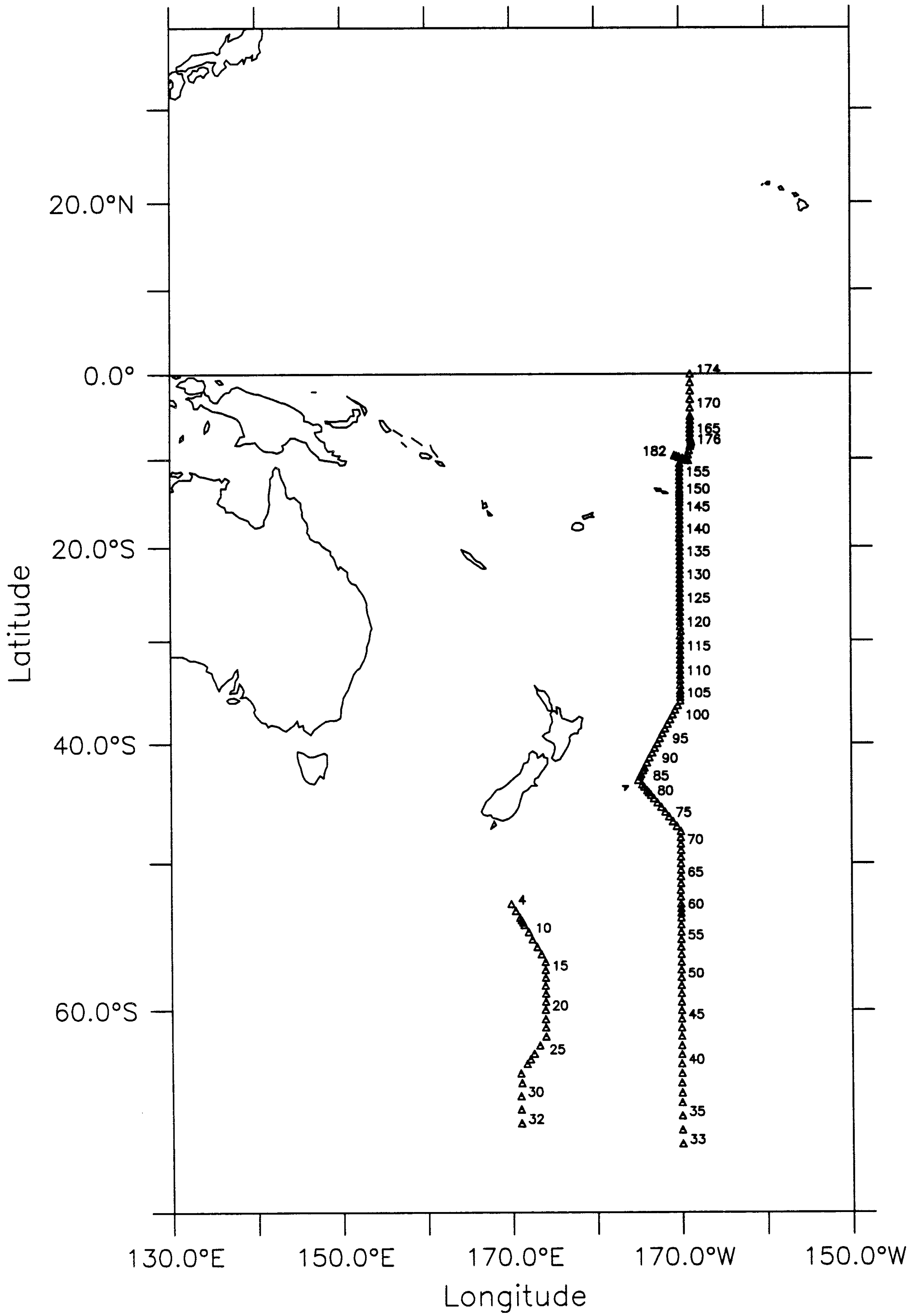


Figure 1: CTD station locations made on the RN Discoverer from January 9 to March 9, 1996.

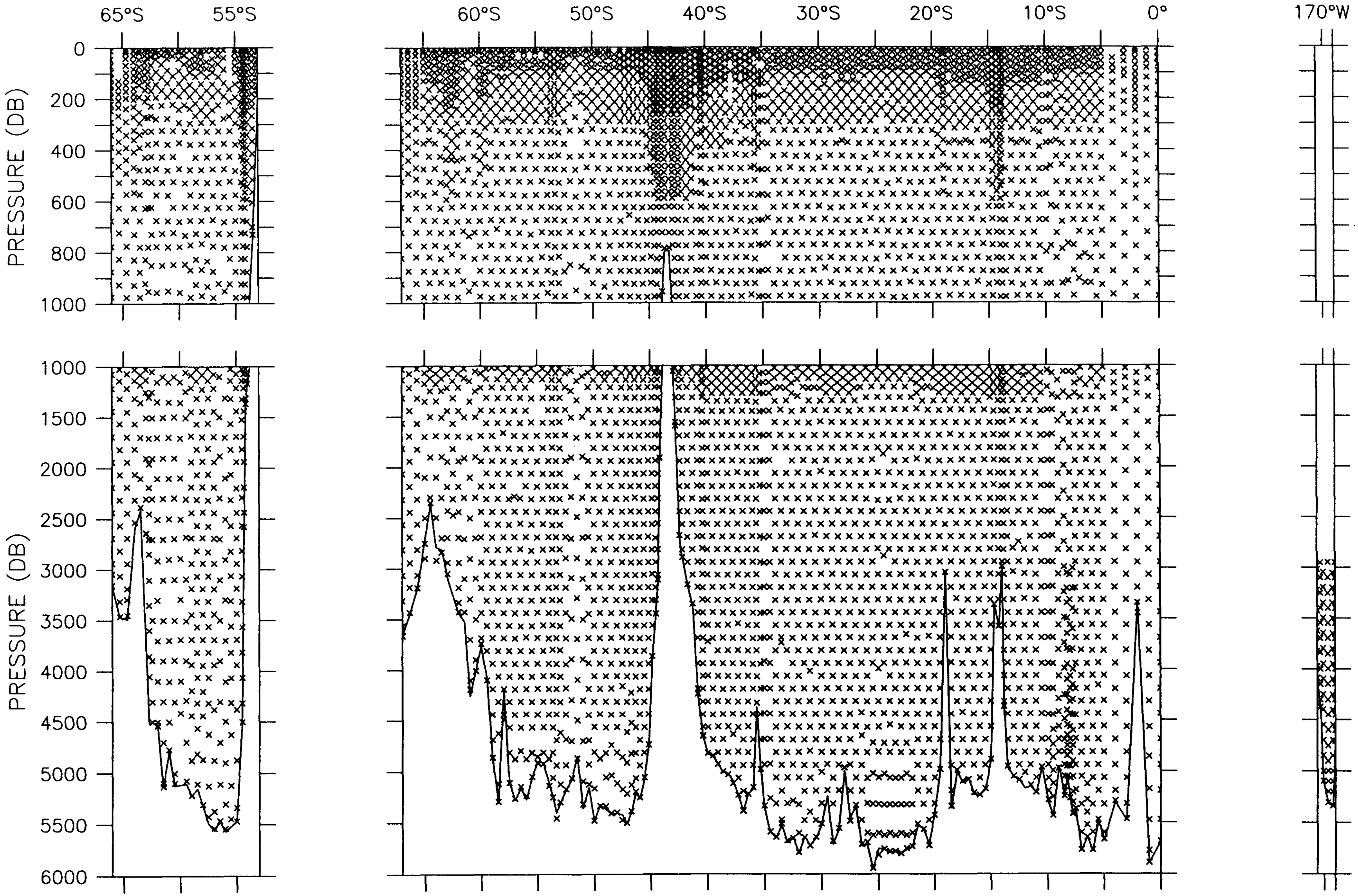


Figure 2: Pressures of bottle closures at each station.

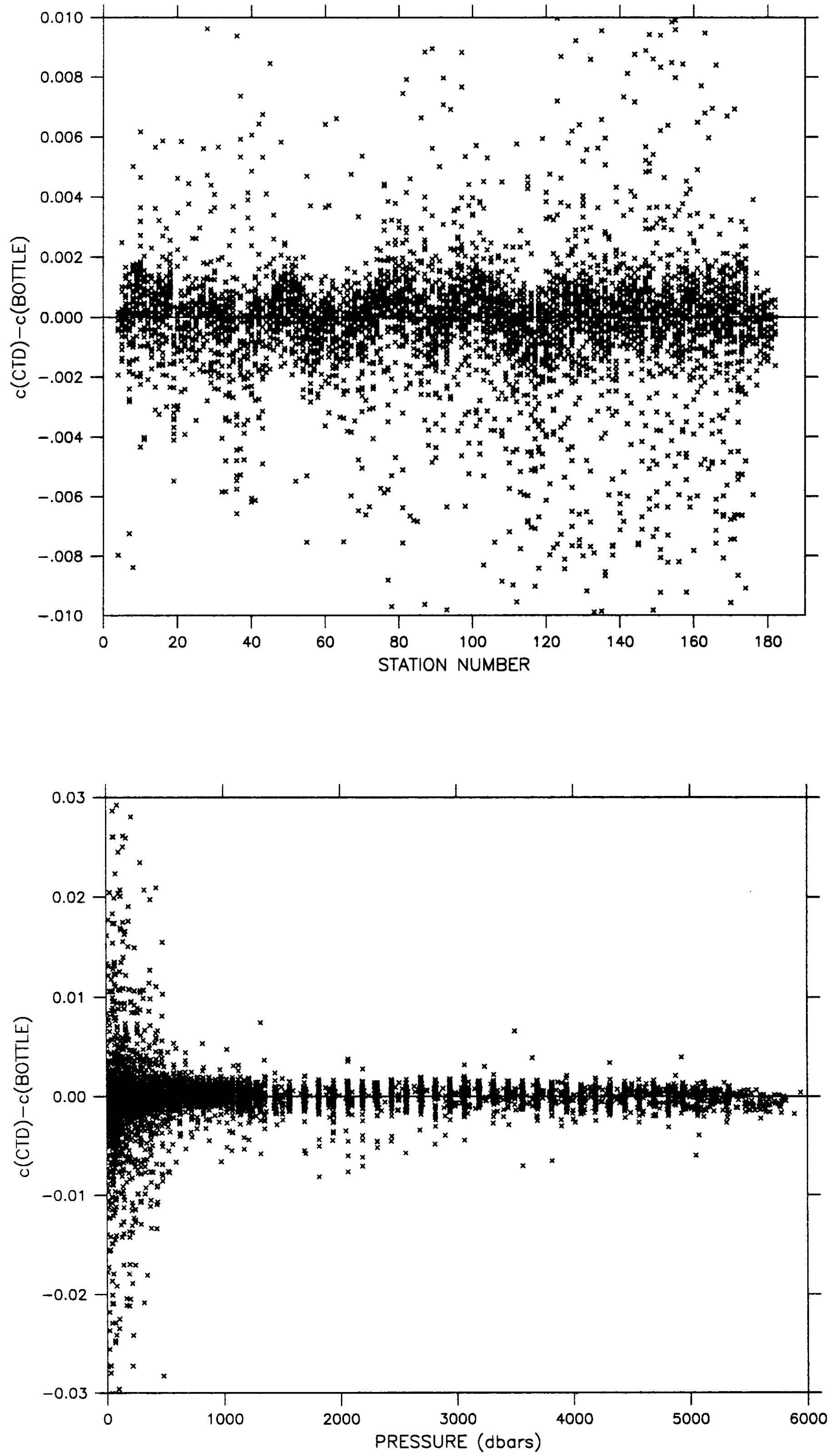
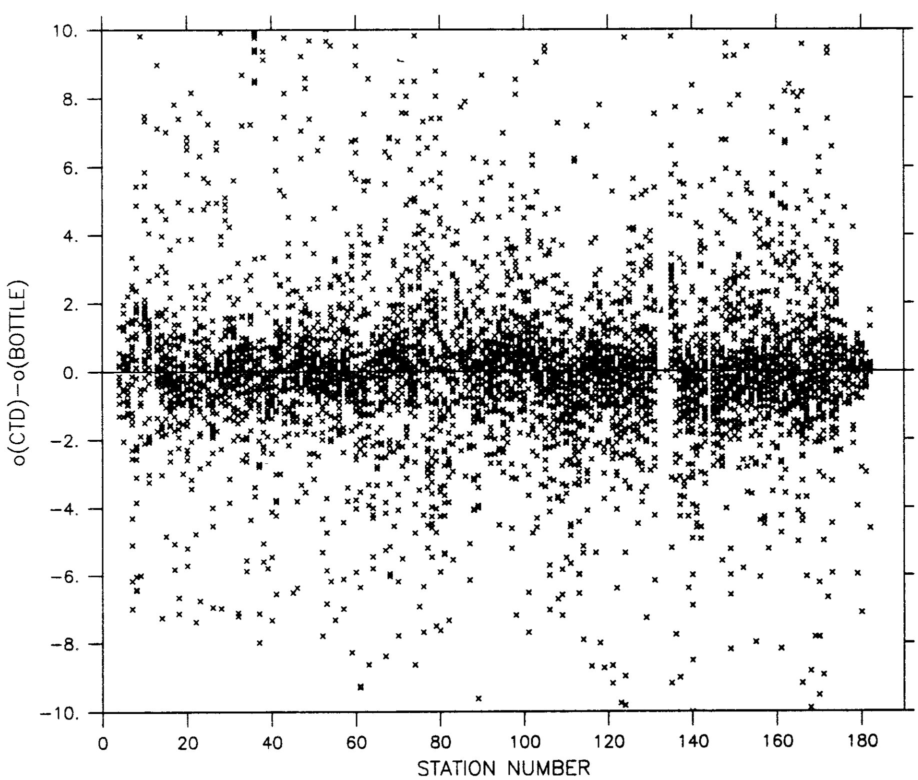


Figure 3: Calibrated CTD-bottle conductivity differences (mS/cm) plotted against station number (upper panel). Calibrated CTD-bottle conductivity differences (mS/cm) plotted against pressure (lower panel).



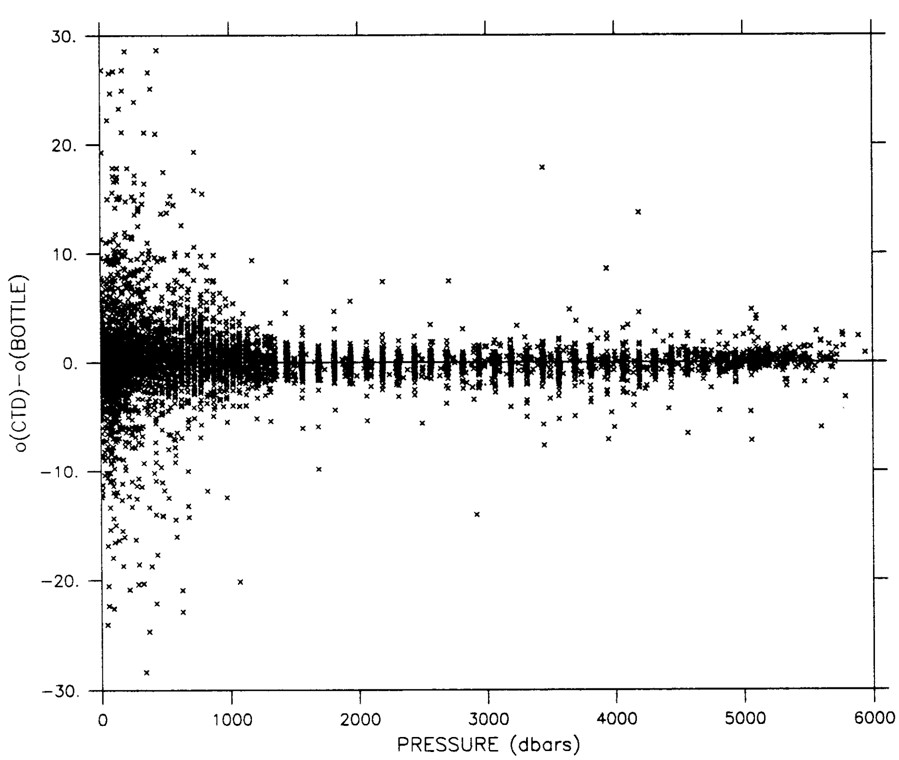


Figure 4: Calibrated CTD-bottle oxygen differences (µmol/kg) plotted against station number (upper panel). Calibrated CTD-bottle oxygen differences (µmol/kg) plotted against pressure (lower panel).

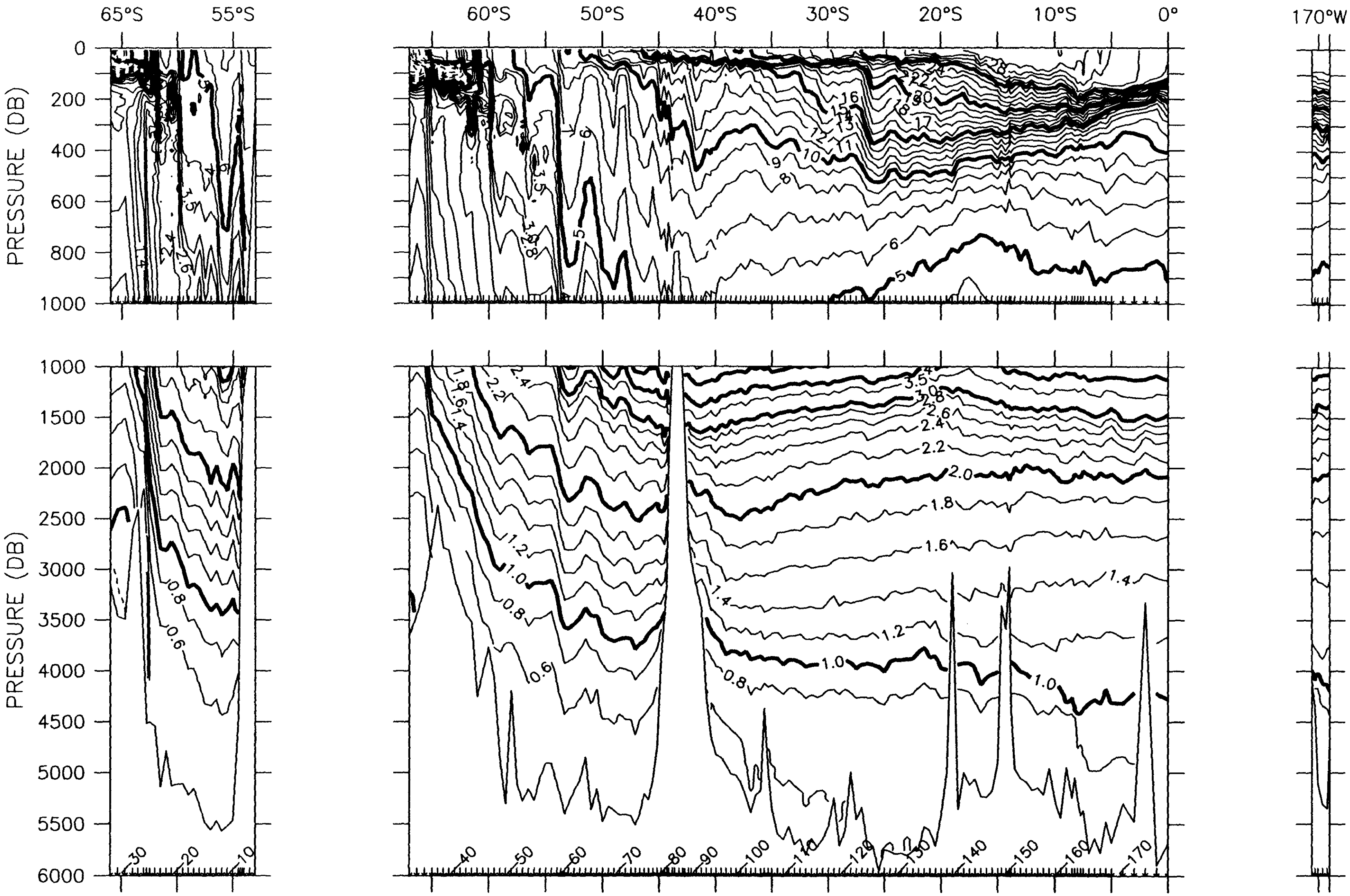


Figure 5: Potential temperature (IC) sections along P14S, P15S, and across the Samoan Passage. Contour intervals are 0.2 from -2-3°C, 0.5 from 3-4°C, and 1 from 4-35°C.

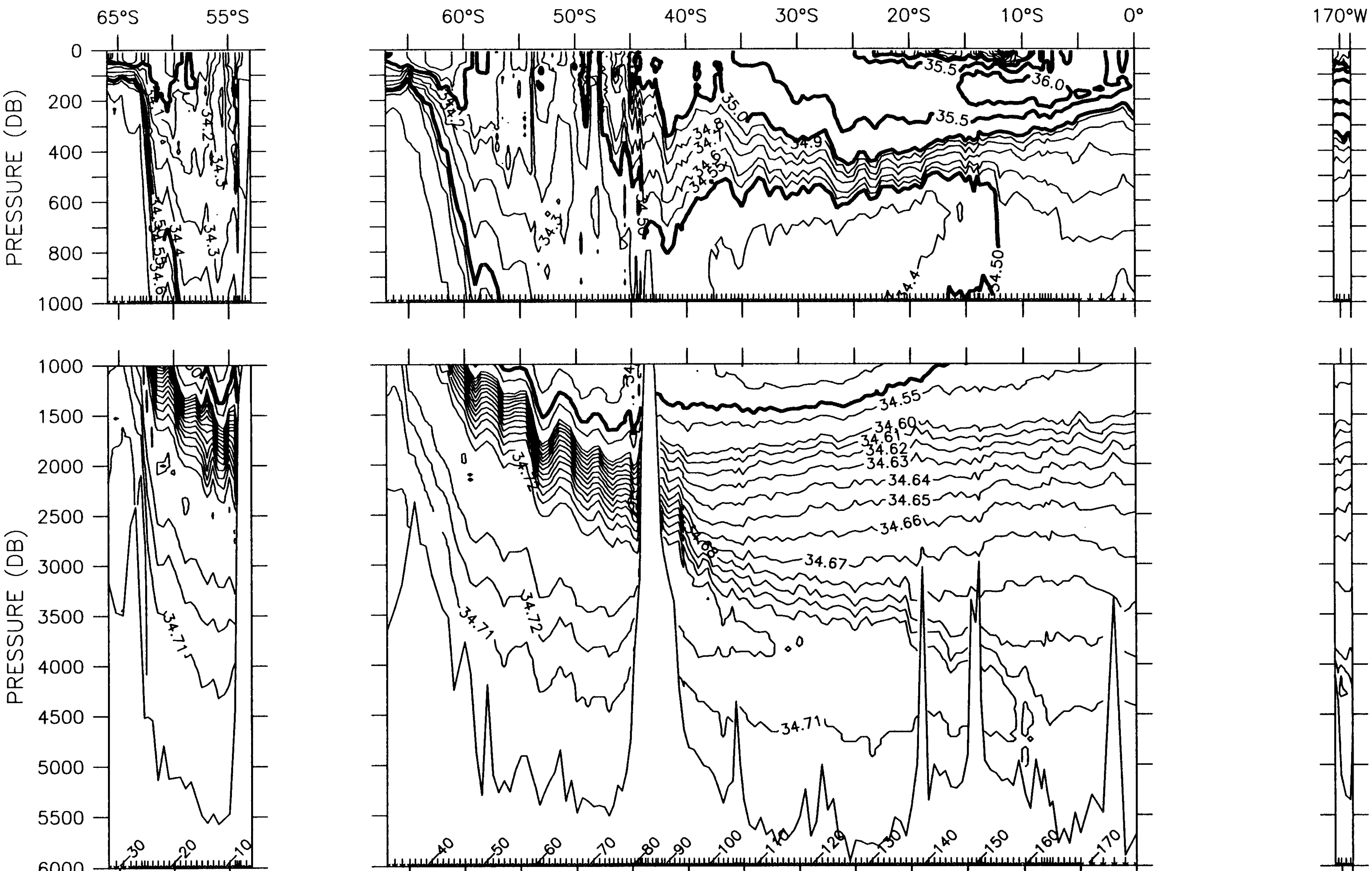


Figure 6: Salinity (PSS) sections along P14S, P15S, and across the Samoan Passage. Contour intervals are 0.1 from 32-34.5 PSS, 0.05 from 34.5-34.6PSS, 0.1 from 34.6-35 PSS, 0.5 from 35-37 PSS in the upper panel. Contour intervals are 0.1 from 32-34.5 PSS, 0.05 from 34.5-34.6 PSS, and 0.0 1 from 34.6-34.8 PSS, 0.1 from 34.8-35, and 1.0 from 35-37 PSS in the lower panel.

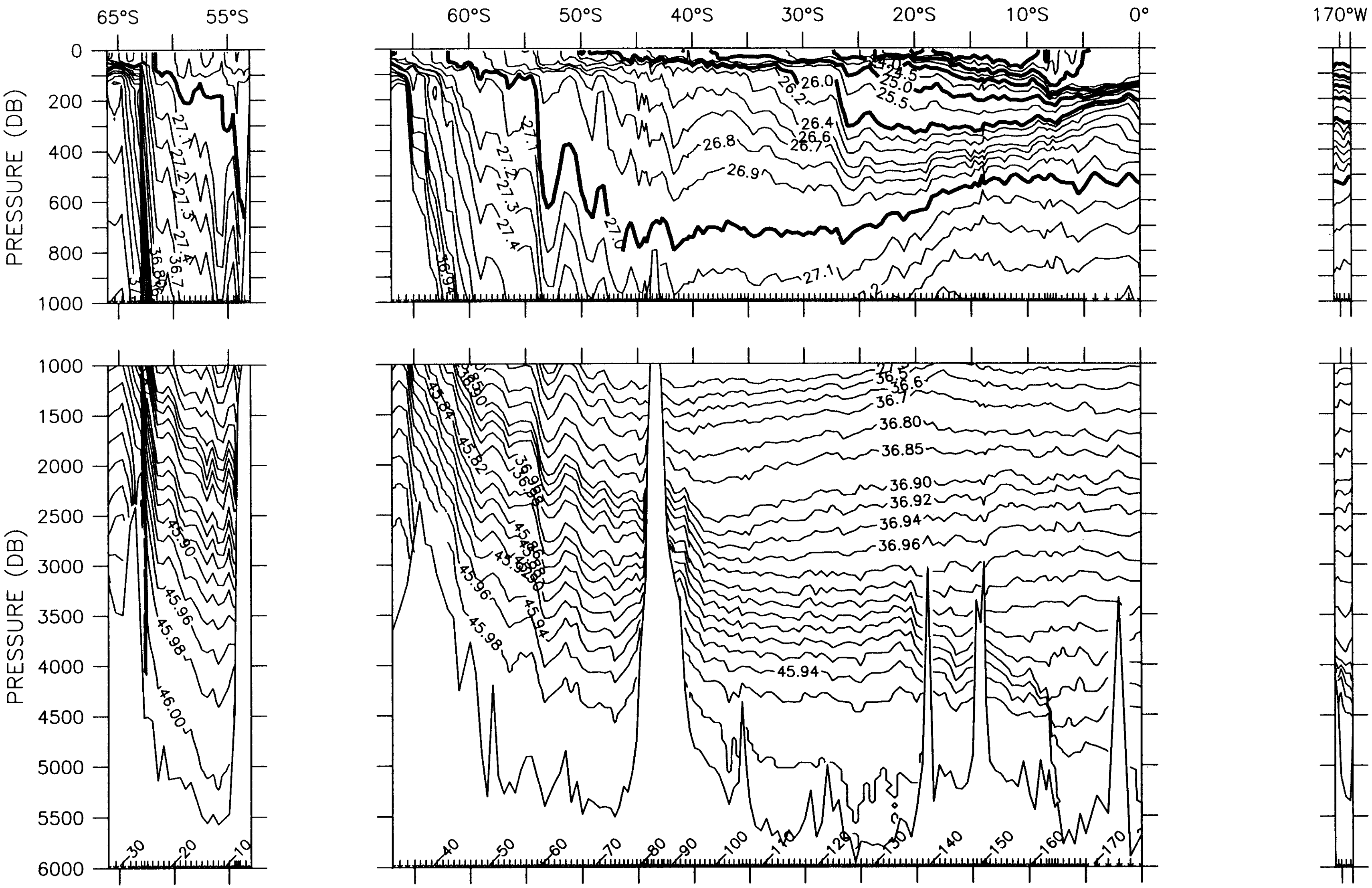


Figure 7: Potential density (kg/m3) sections along P14S, P15S, and across the Samoan Passage. Sigma-theta contour intervals are 0.5 from 22-26, 0.2 from 26-26.6, and 0.1 from 26.6-27.4. Sigma-2 contour intervals are 0.1 from 36.7-36.8, 0.05 from 36.8-36.9, and 0.02 from 36.9-37. Sigma-4 contour intervals are 0.02 from 45.82-48.

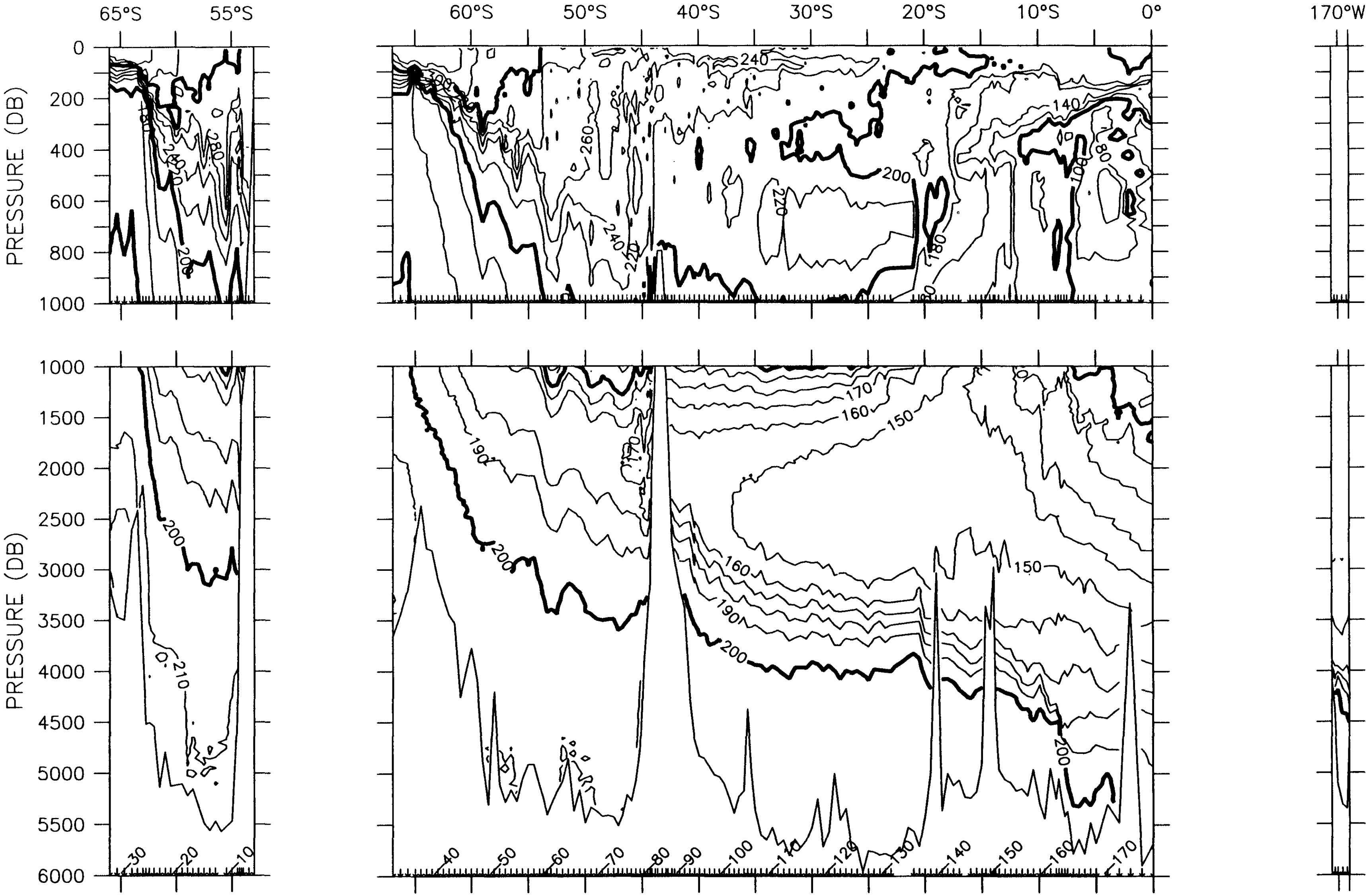


Figure 8: CTD oxygen (µmol/kg) sections along P14S, P15S, and across the Samoan Passage. Contour intervals are 5 from 0-20 µmol/kg and 20 from 20-400 µmol/kg.

D. Data Quality Evaluations

D.1. Hydrographic Data DQE

(Arnold Mantyla - 1998.NOV.18)

The first leg, P14S, was along approximately 170°E southward from Campbell Island to about 66°S, providing an excellent section across the main flow of the Antarctic Circumpolar Current. Data from WOCE section S04 stations 769 to 783 could be tacked onto this section to complete the section to the Antarctic coast at Victoria Land. The cruise continued to 67°S, 170°W to start a long northward section, providing another crossing of the ACC; and then extending through the Samoan Passage on to the equator. There was considerable overlap with P15N. Crossings of P06, P21, p31 and S04 provided comparisons with other WOCE sections as well. The sampling density and data quality for this cruise was quite good on the stations where the 34 place rosette could be used. On the stations where the larger rosette could not be used because of rough weather, the 24 place rosette was still able to get a reasonable profile for the full water column.

The data originators have looked over the data quite thoroughly but they have flagged quite a bit more data as questionable than I would have. In the case of phosphate, many profile bumps of only .01, which is well within measurement uncertainty or even round off truncations, were flagged as uncertain. Unless there was some problem in the measurement, those values should have been accepted as ok.

In the case of salinity, most of the flagged values were in high gradient regions or near sharp extrema in the profiles. There are a number of reasons why the CTD and water samples may not agree perfectly, and yet neither may be "wrong". The two measurements are quite different snapshots of the water column. Ray Weiss's study on the flushing characteristics of oceanographic samplers (DSR 18: 653-656) points out water samples are really "an integration of the water column through which the sampling bottle has been passed"; while the CTD is an instantaneous measure of the ocean that is in the wake of the rosette package. In high gradient regions either measurement can have problems. If the rosette bottle is tripped too quickly, some water will be entrained from below, so the operators usually wait a bit at each stop so as to collect a more representative sample from the target depth, but even a slightly smeared out sample with respect to depth will be acceptable to most data users. CTD processing routines have a number of checks to result in smoother data: pressure reversals (common when a rosette stops), gradient "spikes", statistical tests, and various averaging schemes that can result in a number that is not equivalent to what the rosette bottle is seeing, not to mention that the two types of samplers are usually physically separated in depth. Ideally, the CTD check should be an average of the CTD data just prior to the rosette trip so as to be equivalent to when the rosette sampler is integrating the water column (though stopped, the package moves up and down with the ship roll and changing wire angle).

The purpose of the salinity samples from every rosette bottle is to confirm that the water samples really come from the target depth and verify correct trips and tight seals, or no leakage during the cast. Comparison of the salinometer salinity with the CTD salinity provides a very sensitive validation of the quality of the water samples, and they were usually very good on this cruise. Where differences are greater than that expected from the combined precisions of the two measurements, one looks to see if there could have been a trip problem, leakage, sample collection errors, or analytical errors. It's often a judgement call, but it is not reasonable to believe that sample handling errors occur primarily in the upper water column, where the majority of the u'd values were. A little more care should have been taken to evaluate those apparent salt errors to see if they were possible, given the local gradients.

D.1.1. Flag Changes

I have not changed many of the quality flags, tending to accept the originator's call, but these data are clearly over-edited. The following are a few specific comments that should be looked into:

STATIONS 111-127:

Most have isolated mid-depth bottle salts flagged "u", but examination of the density curves and theta/s curves compared to adjacent stations indicate the bottle salinity is more likely to be correct and the CTD slightly off. I asked Mark Rosenberg to check out stations 116, 117, and 120 and he confirmed that the down CTD trace agreed with the bottle data, so I switched the flags on those stations. However, single values at depths between 1800 and 2400db on the other stations should also be changed to accept the bottle salts as ok (if verified by the down CTD trace).

STATIONS 100, 104, 139, and 163:

These stations have negative oxygen values, either -.78, -.88, or -.98, that may be just a computation residual from a busted analyses. They are flagged as "bad" data, but they are not data at all and should be omitted, and flagged missing or lost.

There are quite a few stations (listed below) that have lines without any data, not even a CTD pressure. Some have nutrients or a salinity, but without a location for the data, they have no value and should not be left in to clutter eventual global archives. I suggest the lines without any pressure information be deleted on stations 25, 26, 31, 36, 37, 39, 41 43-45, 48, 63, 66, 68, 69, 71, 73, 77, 78, 80-83, 91, 95-97, 106, 107, 114, 131, 134, 155, 160, 164, 170, 175-182. Most of these are single lines labeled sample 140 or 240, but others have numerous empty fields.

STATIONS 30-32 PO4's:

Station 32 phosphates below 970db were u'd, apparently because they differ from station 31. However, 32 agrees well with 30, so could station 31 be off instead? All are lower than WOCE S04 PO4's.

STATION 26:

Station 26 is an unusual one; it is in a mid ocean ridge fracture zone and the deep temperatures are much colder than the previous station, indicating the passage is open to the south to the next basin. All phosphates were flagged "u", but if there is not analytical reason to do so, I would change them to ok. They agree well at the same potential temperatures with nearby stations.

Low surface PO4's: Ten stations have zero surface phosphates, unlike any other cruise that I have seen and unlike the NODC Atlas NESDIS 1 for nutrients. Plots of PO4 vs NO3 usually have a positive PO4 intercept at zero NO3 around 0.2 PO4, although values of less than 0.1 (but non-zero) are seen in the western subtropical gyres of the northern hemisphere. PO4/NO3 plots for this cruise compare well with P06 and P15N, except at the surface. Could there be a low level detection problem with the Alpkem AutoAnalyzer? The zero values are suspect, and should be flagged "u". The problem stations are between stations 79 and 147.

STATION 116, 3441db:

The water samples are clearly poor and are not from this level. Salt and 3 of 4 nutrients were u'd, but O_2 and NO_2 were accepted as ok. The CTD confirms the O_2 is poor also, and even though the NO_2 would "fit" at this level, the water did not come from this depth, so all water samples should be u'd.

Below is a list of the lines in the .sea file where the DQE has made changes to the QUALT2 flags.

EXPOCODE 31DSCG96_1, 31DSCG96_2 WHP-ID P14S & P15S DATE 010596 to 031096 19980930WHPOSIOSA

	STN NBR	CAST NO	SAMP NO	BTL NBR	CTD RAW	CTDPRS	CTDTMP	CTDSAL	CTDOXY	THETA	SALNTY	OXYGEN	SILCAT	NIT RAT	NIT RIT	PHS PHT	CFC-11	CFC-12	DEL C14	DEL C13	C14 ERR	C13 ERR	QUALT1	QUALT2
c16	1	1	112	404	-9	1604.8	2.8508	34.5703	154.04	2.7359	34.5732	162.52	-9.00	-9.00	-9.00	-9.00	0.091	0.043	-9.0	-9.0	-9.0	-9.0	2212411916699	2212311916699
c127	4	1	104	1003	-9	117.7	7.1622	34.3993	281.42	7.1512	34.3992	282.10	6.21	17.55	0.35	1.30	4.298	2.228	-9.0	-9.0	-9.0	-9.0	3222233332299	3222222222299
c153	5	1	101	1022	-9	730.0	6.1802	34.3576	237.54	6.1144	34.3574	32.62	15.77	24.36	0.02	1.67	2.780	1.395	-9.0	-9.0	-9.0	-9.0	2222423322299	2222422222299
c180	7	1	127	1234	-9	8.4	7.3430	34.1401	301.74	7.3422	34.1480	298.43	3.36	18.71	0.20	1.28	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222222229999	2223222229999
c296	10	2	211	1114	-9	2690.5	1.6186	34.7383	198.84	1.4278	34.7371	196.92	98.99	31.13	0.00	2.11	0.049	0.022	-9.0	-9.0	-9.0	-9.0	2222266636299	2222266626299
c358	12	2	203	439	-9	4900.2	0.9043	34.7045	174.10	0.5018	34.2147	269.69	13.40	24.68	0.00	1.66	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	4244333239999	4244333339999
c364	13	1	121	417	-9	113.0	6.0008	34.2096	289.67	5.9913	34.2109	280.74	7.60	21.73	0.10	1.43	4.245	2.139	-9.0	-9.0	-9.0	-9.0	2222222222299	2222333332299
c402	14	1	117	1104	-9	1214.0	2.4670	34.5815	177.31	2.3874	-9.0000	179.15	-9.00	-9.00	-9.00	-9.00	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	3225299991199	3225399991199
c528	18	1	127	1234	-9	237.8	4.7880	34.1270	287.94	4.7701	34.1274	294.64	9.21	22.91	0.22	1.56	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222222229999	2222322229999
c532	18	1	123	1250	-9	575.3	3.4305	34.2090	234.77	3.3917	34.2078	241.92	29.11	30.39	0.01	2.05	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222622229999	2222322229999
c543	18	1	112	1217	-9	2440.0	1.7297	34.7410	194.51	1.5594	34.7401	195.95	95.54	31.14	0.00	2.10	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222232229999	2222222229999
c547 550	18	1	108	1263	-9	3443.3	1.0807	34.7185	204.15	0.8305	34.7166	204.31	116.24	32.00	0.00	2.16	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222232229999	2222222229999
	18	1	107	1245	-9	3687.7	0.9947	34.7139	205.88	0.7223	34.7121	206.06	119.55	32.10	0.00	2.17	0.064	0.034	-9.0	-9.0	-9.0	-9.0	2222232222299	2222222222299
	18	1	106	1262	-9	3937.1	0.9228	34.7104	207.69	0.6266	34.7081	207.52	121.94	32.22	0.00	2.18	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222232229999	2222222229999
	18	1	105	1113	-9	4189.5	0.8652	34.7069	208.63	0.5439	34.7046	209.27	124.13	32.30	0.00	2.18	0.101	0.053	-9.0	-9.0	-9.0	-9.0	2222632222299	2222622222299
c645	22	2	206	441	-9	2899.0	1.1234	34.7217	203.40	0.9240	34.7266	202.17	110.16	31.78	0.00	2.16	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	3223266629999	3223366629999
c881	31	2	240	-9	-9	-9.0	-9.0000	-9.0000	-9.00	-9.0000	-9.0000	-9.00	-9.00	-9.00	-9.00	-9.00	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2999999999999	4999999999999
c1038	35	1	108	1263	-9	1819.9	0.5258	34.7017	208.35	0.4248	34.7015	212.68	123.89	32.50	0.00	2.20	0.169	0.098	-9.0	-9.0	-9.0	-9.0	2222222222299	2222322222299
c1070	36	1	101	406	-9	2901.0	0.3685	34.6982	214.11	0.1853	-9.0000	217.54	124.83	32.55	0.00	2.21	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	3229266669991	3229366669991
c1084	37	1	112	404	-9	523.9	1.8990	34.7181	182.81	1.8698	-9.0000	190.80	84.50	31.80	0.00	2.16	0.179	0.121	-9.0	-9.0	-9.0	-9.0	2229222222499	2229322222499
c1118 1119	38	1	102	414	-9	2496.9	0.6984	34.7055	206.81	0.5426	34.7072	212.39	126.37	32.40	0.00	2.19	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222266649999	2222366649999
	38	1	101	406	-9	2918.1	0.7321	34.7056	207.56	0.5395	34.7068	221.63	126.37	32.20	0.00	2.20	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222266669999	2222366669999
c1254	43	1	119	416	-9	164.0	-1.0130	33.9776	282.03	-1.0174	33.9684	347.50	48.12	29.28	0.13	2.06	6.051	2.960	-9.0	-9.0	-9.0	-9.0	2222422222210	2222322222210
c1270	43	1	103	439	-9	2706.8	0.8684	34.7112	206.25	0.6914	34.7334	198.77	103.13	31.53	0.00	2.14	0.058	0.117	-9.0	-9.0	-9.0	-9.0	3224233232410	3224333232410
c1315 1317	45	1	108	440	-9	1502.3	1.9898	34.7290	188.46	1.8930	34.7301	188.18	86.44	31.32	0.00	2.16	0.077	0.038	-9.0	-9.0	-9.0	-9.0	2222222232299	2222222222299
	45	1	107	436	-9	1897.2	1.7051	34.7401	194.05	1.5811	34.7395	194.98	94.56	31.16	0.00	2.15	0.059	0.030	-9.0	-9.0	-9.0	-9.0	2222222232299	2222222222299
	45	1	106	441	-9	2297.6	1.4063	34.7339	198.76	1.2541	34.7337	198.67	103.62	31.43	0.00	2.16	0.049	0.021	-9.0	-9.0	-9.0	-9.0	2222222232299	2222222222299
c1345	46	1	112	1217	-9	1437.1	2.0886	34.7170	184.93	1.9957	34.7161	184.19	83.94	31.87	0.00	2.15	0.098	0.078	-9.0	-9.0	-9.0	-9.0	2222222232490	2222222222490
c1390	47	2	201	1022	-9	4100.7	0.8609	34.7068	209.34	0.5492	34.7057	209.96	123.01	32.27	0.00	2.21	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	3222266669999	3222236669999
c1539	52	1	123	1250	-9	577.2	2.9835	34.2949	212.74	2.9465	33.8992	216.19	41.70	32.55	0.00	2.21	1.930	0.927	-9.0	-9.0	-9.0	-9.0	2224422222290	2224222222290
c1922	63	1	105	423	-9	3495.9	1.2560	34.7237	203.08	0.9961	34.7155	206.36	107.43	31.21	0.00	2.13	0.077	0.043	-9.0	-9.0	-9.0	-9.0	3223233334499	3223333334499
c1935	64	1	116	409	-9	478.4	5.1715	34.2241	262.54	5.1331	34.2565	276.72	7.77	20.14	0.07	1.50	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	4223322229911	4223333339911
c2229	73	1	124	1218	-9	525.8	7.2659	34.4211	251.35	7.2149	34.4244	251.23	8.37	20.71	0.01	1.45	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2223222221199	2222222221199
c2286	74	2	201	1022	-9	5385.3	0.9691	34.7041	209.79	0.5060	34.6873	209.27	119.27	31.77	0.00	-9.00	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	4224233659910	4224333659910
c2492	80	2	201	1022	-9	3448.0	1.2375	34.7220	203.06	0.9829	34.7214	210.74	111.48	31.99	0.00	2.18	0.042	0.151	-9.0	-9.0	-9.0	-9.0	2222266662499	2222366662499
c2512	81	1	116	1211	-9	564.0	7.8179	34.4918	235.88	7.7606	34.5526	229.52	-9.00	-9.00	-9.00	-9.00	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2224299999999	2224399999999
c2843	92	2	202	1030	-9	4190.2	0.9208	34.7076	206.04	0.5978	34.7072	206.36	122.04	32.15	0.00	2.22	0.043	0.028	-9.0	-9.0	-9.0	-9.0	2222222232299	2222222222299
c2845	92	2	201	1022	-9	4237.3	0.9014	34.7065	206.26	0.5738	34.7072	208.69	122.85	32.28	0.00	2.22	0.054	0.126	-9.0	-9.0	-9.0	-9.0	2222266636499	2222266626499
c2968	96	1	122	1265	-9	673.0	7.4823	34.4927	210.85	7.4152	34.4913	211.30	11.27	23.17	0.00	1.57	1.218	0.613	-9.0	-9.0	-9.0	-9.0	2222422222299	2222222222299
c2970	96	1	120	1015	-9	872.8	6.4577	34.4489	198.18	6.3762	34.4482	199.99	20.43	26.40	0.00	1.79	0.548	0.288	-9.0	-9.0	-9.0	-9.0	2222422222299	2222222222299
c2989	96	1	101	1022	-9	4846.1	0.9441	34.7053	208.33	0.5467	34.7049	207.72	123.20	32.39	0.00	2.22	0.069	0.031	-9.0	-9.0	-9.0	-9.0	2222466622299	2222266622299
c3167 3169	101	2	203	999	-9	4807.7	1.0028	34.7083	206.98	0.6078	34.7074	206.16	121.68	32.53	0.00	2.21	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222263629910	2222262629910
	101	2	202	1030	-9	5063.7	1.0137	34.7072	207.80	0.5881	34.7064	202.95	122.18	32.56	0.00	2.21	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222223229910	2222322229910
	101	2	201	1022	-9	5227.8	1.0189	34.7065	207.81	0.5733	34.7066	207.33	122.58	32.54	0.00	2.21	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222263669910	2222262669910
c3344	106	1	107	1263	-9	3443.7	1.6337	34.7153	184.89	1.3697	34.7159	190.60	108.72	32.38	0.00	2.23	0.003	0.002	-9.0	-9.0	-9.0	-9.0	2222222222299	2222322222299
c3462	110	2	234	1216	-9	44.6	20.1116	35.6224	228.82	20.1034	35.6264	233.32	1.22	0.01	0.00	0.10	2.336	1.267	-9.0	-9.0	-9.0	-9.0	2222422226699	2222222226699
c3464	110	2	232	1039	-9	95.7	15.2980	35.4279	240.33	15.2833	35.4331	243.71	1.48	0.28	0.03	0.21	2.748	1.455	-9.0	-9.0	-9.0	-9.0	2222222232299	2222222222299
c3536	112	1	132	1039	-9	94.1	15.8199	35.4880	217.81	15.8051	35.4889	240.41	1.91	0.40	0.05	0.22	2.632	1.398	-9.0	-9.0	-9.0	-9.0	2222222236610	2222222226610
c3556	112	1	112	1217	-9	2689.1	1.9488	34.6579	147.63	1.7520	34.6581	148.39	125.52	36.04	0.00	2.49	-0.001	0.002	-9.0	-9.0	-9.0	-9.0	2222422222210	2222222222210
c3582	113	1	122	1265	-9	927.1	5.4371	34.3316	214.11	5.3575	34.4098	213.22	19.78	28.09	0.00	1.90	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2224322229999	2224222229999
c3587	113	1	117	1267	-9	1816.7	2.4545	34.6015	152.77	2.3269	34.6016	153.95	101.60	35.60	0.00	2.46	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222322229999	2222222229999
c3589	113	1	115	1041	-9	2315.8	2.1241	34.6384	146.58	1.9583	34.6407	146.54	119.45	36.13	0.00	2.51	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222422229999	2222222229999
c3645	115	1	132	1039	-9	113.5	16.2967	35.5503	215.22	16.2784	35.5536	227.46	1.63	1.03	0.10	0.24	2.549	1.354	-9.0	-9.0	-9.0	-9.0	2222222232299	2222222222299
c3651	115	1	126	1025	-9	524.1	8.6264	34.5883	207.21	8.5701	34.5836	207.43	7.19	20.17	0.00	1.38	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2223222229999	2222222229999

EXPOCODE 31DSCG96_1, 31DSCG96_2 WHP-ID P14S & P15S DATE 010596 to 031096 19980930WHPOSIOSA

	STN NBR	CAST NO	SAMP NO	BTL NBR	CTD RAW	CTDPRS	CTDTMP	CTDSAL	CTDOXY	THETA	SALNTY	OXYGEN	SILCAT	NIT RAT	NIT RIT	PHS PHT	CFC-11	CFC-12	DEL C14	DEL C13	C14 ERR	C13 ERR	QUALT1	QUALT2
c3677 3678	116	2	236	1245	-9	4.0	23.5176	35.8167	223.52	23.5167	35.8274	212.22	1.15	0.05	0.00	0.03	1.946	1.078	-9.0	-9.0	-9.0	-9.0	2222222222210	2223222222210
	116	2	235	1113	-9	19.4	23.5276	35.8183	213.91	23.5236	35.8183	222.57	1.16	0.06	0.00	0.03	1.948	1.095	-9.0	-9.0	-9.0	-9.0	2222222222299	2222322222299
c3689	116	2	224	1013	-9	675.2	7.0551	34.4163	227.11	6.9900	34.4164	226.59	8.82	22.83	0.00	1.55	0.966	0.477	-9.0	-9.0	-9.0	-9.0	2222422222299	2222222222299
c3698	116	2	215	1041	-9	2189.2	2.1769	34.6255	146.99	2.0215	34.6341	145.96	117.20	36.20	0.00	2.50	-0.002	0.002	-9.0	-9.0	-9.0	-9.0	2223222222299	2322222222299
c3703	116	2	210	1301	-9	3440.6	1.6287	34.7042	175.73	1.3652	34.6753	157.91	123.48	35.26	0.00	2.43	-0.001	0.003	-9.0	-9.0	-9.0	-9.0	3224233232299	3224333332299
c3734 3735	117	1	115	1041	-9	2046.1	2.2843	34.6220	147.78	2.1395	34.6262	147.52	112.57	35.84	0.00	2.49	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2223222229990	2322222229990
	117	1	114	1017	-9	2315.9	2.1070	34.6356	146.42	1.9415	34.6419	145.76	120.96	36.08	0.00	2.51	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2223222229990	2322222229990
c3744	117	1	105	1264	-9	4564.6	1.0366	34.7103	206.04	0.6685	34.7127	205.87	119.61	32.11	0.00	2.21	0.009	0.006	-9.0	-9.0	-9.0	-9.0	2222222232290	2222222222290
c3821	120	2	236	1245	-9	4.7	23.9467	35.8507	213.93	23.9457	35.8641	211.66	1.30	0.02	0.00	0.03	1.933	1.119	-9.0	-9.0	-9.0	-9.0	2222222222210	2323222222210
c3843 3844	120	2	214	1017	-9	2189.3	2.1045	34.6325	145.78	1.9501	34.6400	145.96	120.13	36.07	0.00	2.51	-0.001	0.004	-9.0	-9.0	-9.0	-9.0	2223222222299	2222222222299
	120	2	213	1302	-9	2439.1	1.9871	34.6471	146.09	1.8126	34.6520	145.47	125.28	36.18	0.00	2.51	0.001	0.003	-9.0	-9.0	-9.0	-9.0	2223222222299	2222222222299
c3951	123	1	114	1017	-9	2064.3	2.1895	34.6222	145.70	2.0447	34.6315	145.77	117.53	36.25	0.00	2.50	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2223222229999	2222222229999
c4013	125	3	324	1013	-9	720.1	6.9901	34.4017	230.38	6.9208	34.4056	228.05	8.70	22.71	0.00	1.55	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2223222229999	2222222229999
c4095 4107	127	2	214	1017	-9	2559.0	1.8973	34.6520	145.97	1.7135	34.6590	145.66	128.66	36.13	0.00	2.53	-0.001	0.000	-9.0	-9.0	-9.0	-9.0	2223222222290	2322222222290
	127	2	213	1302	-9	2810.0	1.8188	34.6602	146.34	1.6132	34.6661	146.63	131.92	36.18	0.00	2.52	0.002	0.002	-9.0	-9.0	-9.0	-9.0	2223222222290	2322222222290
	127	2	212	1217	-9	3065.2	1.7567	34.6679	147.91	1.5279	34.6704	148.97	132.89	35.94	0.00	2.51	0.003	0.001	-9.0	-9.0	-9.0	-9.0	2222222222290	2322222222290
	127	2	211	1114	-9	3315.0	1.6346	34.6811	155.99	1.3838	34.6830	158.01	131.06	35.28	0.00	2.46	0.002	0.002	-9.0	-9.0	-9.0	-9.0	2222222222290	2322222222290
	127	2	210	1301	-9	3565.8	1.5221	34.6942	175.79	1.2485	34.7028	178.44	119.58	33.49	0.00	2.32	0.001	0.002	-9.0	-9.0	-9.0	-9.0	2223222226690	2322222226690
	127	2	209	1233	-9	3815.3	1.4040	34.7125	193.65	1.1073	34.7205	194.88	111.50	32.14	0.00	2.21	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	3223222229990	3322222229990
	127	2	208	1227	-9	3992.6	1.3077	34.7164	198.57	0.9948	34.7185	199.26	112.17	31.94	0.00	2.20	0.005	0.003	-9.0	-9.0	-9.0	-9.0	2222222222290	2322222222290
	127	2	207	1263	-9	4316.1	1.1466	34.7123	203.32	0.8030	34.7144	203.93	115.99	32.01	0.00	2.20	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222222229990	2322222229990
	127	2	206	1262	-9	4566.6	1.0717	34.7095	205.05	0.7023	34.7111	205.58	118.71	32.16	0.00	2.21	0.011	0.005	-9.0	-9.0	-9.0	-9.0	2222222222290	2322222222290
	127	2	205	1264	-9	4811.8	1.0511	34.7077	205.50	0.6540	34.7093	206.36	119.83	32.19	0.00	2.21	0.012	0.006	-9.0	-9.0	-9.0	-9.0	2222622222290	2322622222290
	127	2	204	1003	-9	5061.5	1.0523	34.7067	206.09	0.6257	34.7085	206.26	120.78	32.22	0.00	2.21	0.009	0.005	-9.0	-9.0	-9.0	-9.0	2222222222290	2322222222290
	127	2	203	1035	-9	5321.2	1.0691	34.7067	190.77	0.6103	34.7088	206.65	121.16	32.25	0.00	2.22	0.009	0.006	-9.0	-9.0	-9.0	-9.0	2242222222290	2342222222290
	127	2	202	1030	-9	5602.1	1.0978	34.7062	206.37	0.6028	34.7089	208.01	121.36	32.27	0.00	2.21	0.012	0.007	-9.0	-9.0	-9.0	-9.0	2242222222290	2342222222290
c4254	132	1	136	1245	-9	5.1	27.8460	34.7999	-9.00	27.8448	34.8053	199.16	1.02	0.02	0.00	0.00	1.637	0.959	-9.0	-9.0	-9.0	-9.0	2292622222210	2293622222210
c4373 4374	135	2	226	1025	-9	527.7	8.4781	34.5337	201.07	8.4221	34.5336	204.22	9.11	22.92	0.00	1.58	1.131	0.555	-9.0	-9.0	-9.0	-9.0	2222222222210	2222233332210
	135	2	225	1119	-9	625.5	6.9897	34.4038	223.91	6.9299	34.4054	224.06	9.13	22.96	0.00	1.58	0.942	0.466	-9.0	-9.0	-9.0	-9.0	2222222222210	2222233332210
c4793	146	1	102	1030	-9	4940.2	1.0523	34.7090	206.05	0.6401	34.7097	207.91	120.70	32.25	0.00	2.21	0.007	0.003	-9.0	-9.0	-9.0	-9.0	2222222226610	2223222226610
c4811	147	1	120	1015	-9	829.0	4.7780	34.4723	148.90	4.7114	34.4689	147.28	53.59	33.97	0.00	2.36	0.023	0.009	-9.0	-9.0	-9.0	-9.0	2223222222299	2222222222299
c5059	154	1	124	1244	-9	575.5	6.6821	34.4886	153.19	6.6285	34.4854	148.48	30.37	30.54	0.00	2.11	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2223222229999	2222222229999
c5114	155	1	106	1262	-9	3815.6	1.4825	34.6898	165.83	1.1838	34.6922	166.18	132.95	35.15	0.00	2.40	-0.001	0.000	-9.0	-9.0	-9.0	-9.0	2222222222299	2222223222299
c5452	165	1	130	1257	-9	213.6	20.5119	35.8367	145.40	20.4715	35.9834	150.40	2.31	6.96	0.01	0.71	1.965	1.055	-9.0	-9.0	-9.0	-9.0	2224222222210	2223222222210
c5483	166	2	235	1113	-9	21.7	28.8105	35.4380	194.94	28.8053	35.5323	196.00	1.52	0.10	0.01	0.22	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2223222229999	2322222229999
c5637	170	1	125	1119	-9	573.6	7.4558	34.6053	47.04	7.3990	34.6018	44.01	44.91	39.55	0.00	2.75	0.011	0.005	-9.0	-9.0	-9.0	-9.0	2223622222299	2222622222299
c5688	171	1	110	1301	-9	3314.3	1.5556	34.6817	148.42	1.3068	34.6842	153.44	140.83	35.86	0.00	2.47	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222222221199	2223333331199
c5699	172	2	235	1113	-9	10.0	26.5125	35.3942	201.31	26.5102	35.4018	201.33	2.84	4.37	0.32	0.48	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	2222222229910	2223222229910
c5737	173	2	233	1021	-9	81.0	26.6480	35.5076	200.63	26.6296	35.5114	200.45	2.55	4.02	0.32	0.49	1.719	1.101	-9.0	-9.0	-9.0	-9.0	2222322223399	2222222223399
c5742	173	2	228	1230	-9	326.4	10.8877	34.7808	69.58	10.8475	34.7792	70.52	25.57	29.37	0.00	2.05	0.379	0.223	-9.0	-9.0	-9.0	-9.0	2222322222399	2222222222399
c5866	176	1	112	1217	-9	3648.1	1.4940	34.6875	162.59	1.2126	34.6827	157.82	135.40	35.75	0.00	2.46	-0.002	-0.001	-9.0	-9.0	-9.0	-9.0	2223666662499	2223366662499
c5947	178	1	103	1302	-9	5100.1	1.0852	34.7087	205.62	0.6528	34.7089	201.39	120.21	32.46	0.00	2.21	0.003	0.001	-9.0	-9.0	-9.0	-9.0	2222222222299	2222322222299

D.1.2. Responses to WOCE DQE comments on initial .sea file

We have removed 4 oxygen values that were 'lost' data.

We have removed samples where no CTD pressures or other parameters were reported. We have left in some samples (typically sample '140') which were surface samples collected from the underway pumping system while on station. These samples we analysed for tcarbn and alkali, and although no CTD values are available, we feel it is useful to include them in th file for completeness.

We have adopted most of the suggested changes in the salnty, ctdsal and oxygen flags suggested by A. Mantyla.

The following response to the Nutrient DQE comments was provided by Calvin Mordy:

Changes to Version 8 of P15/P14S Nutrient Data (6/8/00)

CWM-initiated edits:		
45	102-105	Changed PO4 flag from 2 to 6 (oversight)
139	108	Changed PO4 flag from 5 to 3 (typo)

A. Mantyla-initiated PO4 edits:		
32	REJECTED	Deep water remains flagged as 4 due to DOC phosphoric acid contamination
26	ACCEPTED	Changed flag to 2 or 6 except for bottle 3 (QF=3)
83-142	ACCEPTED	Shallow PO4s less than 0.4 µmol/kg were flagged as questionable.

ACCEPTED changes suggested by A. Mantyla (FLAG = SIL/NO3/NO2/PO4)

STN	BOTTLE	OLD FLAG	NEW FLAG	
4	104	3333	2222	
5	101	2332	2222	
12	203	3323	3333	
13	121	2222	3333	
18	105-108,112	3222	2222	Reruns due to bubble in flowcell look ok
45	106-108	2223	2222	
46	112	2223	2222	
64	116	2222	3333	
92	201,202	2223	2222	
110	232	2223	2222	
112	132	2223	2222	
115	132	2223	2222	
116	210	3323	3333	
117	105	2223	2222	
135	225,226	2222	3333	
171	110	2222	3333	

REJECTED changes suggested by A. Mantyla (FLAG = SIL/NO3/NO2/PO4)

STN	BOT	FLAG	Rejected Flag	COMMENT
10	211	6663	6662	Air bubble in PO4 peak, rerun was suspect
47	201	6666	3666	No problem with silicic acid peak or concentration
101	201	6366	6266	Peak corrected for severe bubble drift, still questionable
101	202	2322	2222	Peak corrected for severe bubble drift, still questionable
101	203	6362	6262	Peak corrected for severe bubble drift, still questionable
155	106	2222	2322	NO3 peak is ok, not a flier

D.2. CTD Data DQE

(Mark Rosenberg - October 1998)

This report contains a data quality evaluation of the CTD data files for the Pacific sector cruise along WOCE meridional sections P14S and P15S (Figure 1) on the RV Discoverer in January to March, 1996. Bottle data are evaluated by Arnold Mantyla in a separate report. The data are in general of good quality, and help to fill a former sampling void for the Southern Ocean in particular. Notably, the P15S section provides a contiguous high density sampling through tropical, subtropical and Antarctic waters, crossing several major fronts. The most significant problem is the biasing of CTD salinity data for individual stations, as detailed below. Note that the comments in this report are offered as suggestions (hopefully helpful ones) from an outside perspective, focussing on various data and methodology problems. They are not intended to detract from the general high standard and usefulness of the data set.

STATION SUMMARY FILE (.sum)

- Stations 21 and 77 are listed as cast 2 in .sum and .ctd files, but cast 1 in .sea file - needs clarification.
- The uncorrected sounder depth at the bottom of the cast appears wrong for stations 44 and 50, as follows (N.B. depth from CTD = altimeter reading + maximum pressure recalculated in meters):

Station	depth from CTD (m)	wire out (m)	sounder depth at bottom of cast (m)
44	4134	4114	3630
50	4409	4423	4140

- Sound speed and transducer depth information for the ship's sounder were not provided in the documentation. "Corrected depth" in the .sum file was therefore calculated from the CTD at the bottom of the cast i.e. altimeter reading + maximum CTD pressure recalculated in meters (using the method of Saunders and Fofonoff, 1976). For stations with no altimeter reading, no corrected depth was calculated. These corrected depth values are in an ascii file corrdepth.dat, and have not been merged into the .sum file.

D.2.1 Salinity

In the following discussion, only CTD and bottle values with a quality flag of 2 are considered (i.e. QUALT1=2 for CTDSAL and SALNTY in the .sea file). See Table 3 for a station by station summary of data problems.

Scatter of salinity residuals

The salinity residual data δS (where δS = bottle - CTD salinity difference) for all depths is shown in Figure 2. Outliers were rejected iteratively by the data processors, as described in the cruise report. Below 500 dbar, scatter of δS is greatly reduced (Figure 3), so the outliers are from samples shallower than 500 dbar. Much of the scatter for the shallower samples is no doubt due to sampling errors in steep vertical gradients. However, the sign of δS can not always be reconciled with the direction of the vertical salinity gradient (assuming here that the CTD sensors are below the Niskin bottles on the rosette package). It may be possible to improve this scatter by increasing the averaging period for the upcast CTD burst data from 2 seconds to 10 seconds. This larger averaging period more closely matches the swell wave period, and may better average out the effect of the rolling ship during bottle stops.

Biasing of CTD salinity data for individual stations

Standard deviations for δS for the whole cruise were calculated from data in the .sea file ("uncorrected data" in Table 1). The value of 0.0018, calculated using all sampling depths and $|\delta S| \leq 0.008$, is a reasonable estimate of the salinity accuracy for the cruise (note that 0.008 ~ 2.8*0.0029, where 0.0029 is the standard deviation for all bottles from Table 1). When the cruise is viewed as a whole, this salinity accuracy meets WOCE requirements and δS varies about a mean of zero (Figures 2 and 3). However when individual stations are examined, there is a significant problem with biasing of the CTD salinity data (Table 3). This is clearly evident through visual examination of Figures 2 and 3: the mean value of δS for each station varies (a good example is for stations 46 to 53, where δS is clearly negative).

The biasing is a direct result of the conductivity calibration method as described in the cruise report, where the whole cruise is fitted in one group and the fourth order station dependent slope correction fails to fully track the variation of conductivity sensor behaviour over the cruise. Breaking down the stations into smaller calibration groups is strongly recommended - this would allow the station dependent slope correction to remove the bias for individual stations.

To prove this point, I've done an extra fit to the δS data to minimize the residuals and biasing, as follows. Note that back-calculating conductivity made no difference to the resulting corrections, so salinity was used. Firstly, Figure 3 was examined and station groups formed to reflect the variation through the cruise of mean δS for each station (Table 2). Next, samples for which $|\delta S| > 0.008$ were rejected. A linear fit of CTD to bottle salinity (i.e. S_{ctd} to S_{btl}) was then found for each station group:

$$S_{ctd} = a_1 S_{btl} + a_2$$

for fit coefficients a_1 and a_2. Lastly, corrected salinity S_{cor} was calculated for each station group:

$$S_{cor} = (S_{ctd} - a_2) / a1$$

The resulting $S_{btl} - S_{cor}$ residuals are plotted in Figure 4 (all depths) and Figure 5 (deeper than 500 dbar). Standard deviation calculations for these "corrected" data are shown in Table 1.

As expected, there is only a small improvement to standard deviations calculated for the whole cruise (Table 1). The important point is the marked improvement to the biasing of individual stations, revealed by comparing Figure 5 to Figure 3. Corrected and uncorrected δS vertical profiles for a few example stations are plotted in Figure 6. Stations for which the correction improves salinity biasing are indicated in Table 3.

I hope this does not put too fine a point on the conductivity calibration. True, the salinity biasing errors for the submitted data are less than 0.002, however δS values for each station ought to be scattered around a mean value of zero. Clearly, breaking down a cruise into smaller station groups for the calibration of CTD conductivity significantly improves the calibration. Note that the correction done here is only a rough version - for a real calibration on selected station groups, groups would be selected with a linear variation of station mean δS, allowing the station dependent slope correction to take effect within each group and giving even better calibration results.

Table 1: Standard deviations for salinity residuals δS (using only bottle and CTD data for which the quality flag=2), where "uncorrected data" are as submitted to WHPO, and corrected data are with additional δS fit applied.

Data	Standard Deviation of δS, Uncorrected Data	Standard Deviation of δS, Corrected Data
all depths	0.0029	0.0028
deeper than 500 dbar	0.0010	0.0009
all depths, |δS| ≤ 0.008	0.0018	0.0017

Table 2: Station grouping used for additional fit of salinity residuals.

1-3	41-45	75-80	133-137	162-174
4-8	46-53	81-99	138-146	175-182
9-18	54-59	100-105	147-148	
19-25	60-62	106-109	149-151	
26-30	63-65	110-121	152-154	
31-35	66-70	122-129	155-157	
36-40	71-74	130-132	158-161	

PROBLEM SALINITY BOTTLE DATA

Comparing bottle salinity values for adjacent stations on deepwater θS curves, the following problems were found:

Station	Problem	Recommendation
19	bottle salts high by ~0.002	don't use in calibration
49	bottle salts low by ~0.001	don't use in calibration
117	bottle salts high by ~0.002	don't use in calibration
164	bottle salts low by ~0.001	don't use in calibration

D.2.2. Oxygen

The CTD oxygen data are of the highest quality. Calibration results are excellent, and oxygen profiles are remarkably free of noise. The Seabird design of constant flow past the oxygen sensor membrane appears to have merit. Due to the inherent small scale variability of membrane-type oxygen sensors, I do not believe the concerns expressed about data despiking later in this report are relevant here. Oxygen residual data are plotted in Figure 7, noting that large outliers lie beyond the axis limits on the graph.

Many stations appear to have suspicious oxygen data for the top few bins, due to transient sensor errors as the instrument enters the water and the pump winds up, combined with the despiking errors discussed below. Stations where these errors are greater than ~4 µmol/kg, and where there is no matching T/S feature, are summarized in Table 4, and a quality flag of "3" is recommended for bins not already flagged as "7" in the .ctd files. Also listed in Table 4 are a few stations where most of the CTD oxygen profile has a constant offset from the bottle values. In all cases the offset is small (~1%), however given the high quality of the CTD oxygen data set these stations are worth pointing out.

D.2.3. Temperature

The following temperature spikes were identified in the .ctd files:

station 43:	very spikey T structure between 100 and 300 dbar on downcast	not reflected in salinity - would like to confirm with upcast CTD temperature
station 45:	temperature spike at 9 dbar	flag as 3 in .ctd file
station 49:	temperature spike at 8-11 dbar	flag as 3 in .ctd file
station 54:	small temperature spike at 7 dbar	status uncertain due to despiking of salinity data
station 60:	small temperature spike at 5-6 dbar	status uncertain due to despiking of salinity data
station 64:	small temperature spike at 7-8 dbar	status uncertain due to despiking of salinity data
station 106:	small temperature spike at 7 dbar	status uncertain due to despiking of salinity data
station 108:	small temperature spike at 4 dbar	status uncertain due to despiking of salinity data

D.2.3.1. Despiking and Interpolation

There is a large number of interpolated CTD temperature and salinity values in the .ctd files, flagged as "6". This needs an explanation i.e. is it due to fouling of the pump line, data dropouts from the instrument or some other electronic problem? Or is it mainly due to interpolations from the program DELOOP mentioned in the cruise report?

I have concerns about despiking of the temperature and salinity data (program DESPIKE mentioned in the cruise report). In particular, salinity data near the surface is often continued to the surface as an identical value from the first good data bin a few decibars down, and flagged as "7" (program FILLSFC mentioned in the cruise report). As a result, temperature features are often not reflected in the salinity data (e.g. Figure 8), and density inversions can occur. In some instances, erroneous salinity features may appear (e.g. station 159, top 9 dbar in Figure 8). Rather than inserting these fictional salinity data near the surface, it might be preferable to leave the original bad data there and flag as "3" or "4", or else remove the data entirely. In general, all data in the top 15 dbar with a "7" flag should be regarded as questionable.

D.2.3.2. Density Inversions

Locations of unstable vertical density gradients are shown in Figure 9; only gradients more unstable than -0.003 kg/m3/dbar are shown. Unstable density gradient values are summarized in Table 5. All except for station 40 occur in the top 20 dbar. In addition, almost all occur where the CTD salinity data has been "despiked" (flag 7 in the .ctd file). The worst instance is for station 78 at 9 dbar: a temperature feature occurs at this level, however the salinity data has been artificially smoothed, leaving a large density instability.

D.2.4. INTRA-CRUISE COMPARISON

Deepwater θS and θoxygen curves compare well for the coincident station pair 93/94. More variability is evident for the station pair 159/179.

Comparisons With Other Cruises

Deepwater θS and θoxygen curves were compared for P15S stations coincident with other cruise data sets, as follows. In general, there is reasonable consistency between the different data sets.

P15S and P15N	(P.I. H. Freeland) (Figure 10) P15N salinity lower than P15S by on average 0.001. No CTD oxygen data for P15N.
P15S and P31	(P.I. D. Roemmich) (Figure 11) P31 salinity lower than P15S by on average 0.001. Oxygen data compare well.
P15S and P21	(P.I. H. Bryden on western leg) (Figure 12) Limited data only for comparison, and stations separated longitudinally by 19 miles. P21 salinity higher than P15S by ~0.001 above (θ=1.3°; compare well at bottom. Oxygen data compare well below θ=1.25°
P15S and P6	(P.I. M. McCartney on central leg) (Figure 12) Limited data only for comparison, and stations separated longitudinally by up to 12 miles. Salinity data compare well. Oxygen data compare well around the oxygen minimum; at the bottom, P06 is higher by ~2µmol/kg
P15S and S4P	(P.I. Koshlyakov) (Figure 12) Limited data only for comparison, and stations separated longitudinally by up to 17.5 miles. S04P salinity lower by ~0.0015. Oxygen data a bit variable, but within ~1%.

DOCUMENTATION

The documentation is good and thorough. It would be useful to add the following information:

* PDR sound speed used for sounder readings, and whether or not readings have been corrected for transducer depth below the waterline;
* criteria used for despiking.

CTD DQE REFERENCES

Saunders, P.M. and Fofonoff, N.P., 1976. Conversion of pressure to depth in the ocean. Deep Sea Research, 23:109-111.

Table 3: Suspicious CTD salinity (S_{ctd}) data. * Indicates calibration improved by additional correction described in the text (i.e. using smaller station groupings).

station	comment	recommendation
*8	S_{ctd} high by ~0.001 below 1500 dbar (impressive interfingering for this station!)	use smaller station groupings
*9	S_{ctd} high by ~0.0015 for whole profile	use smaller station groupings
*10	S_{ctd} high by ~0.001 for whole profile	use smaller station groupings
*11	S_{ctd} high by ~0.001 for whole profile	use smaller station groupings
*13	S_{ctd} high by ~0.001 below 1500 dbar	use smaller station groupings
*15	S_{ctd} high by ~0.001 below 2000 dbar	use smaller station groupings
*16	S_{ctd} high by ~0.001 below 2000 dbar	use smaller station groupings
*17	S_{ctd} high by ~0.001 for whole profile	use smaller station groupings
*18	S_{ctd} high by ~0.0015 for whole profile	use smaller station groupings
23	S_{ctd} high by ~0.001 below 1000 dbar	possibly due to bottles
*26	S_{ctd} high by ~0.001 for whole profile (interesting T feature at 2600 dbar on downcast)	use smaller station groupings
*27	S_{ctd} high by ~0.001 for whole profile	use smaller station groupings
*29	S_{ctd} high by ~0.001 below 800 dbar, low at surface	use smaller station groupings
37	S_{ctd} low by ~0.001 below 1000 dbar	
38	S_{ctd} low by ~0.001 for whole profile	
*41	S_{ctd} high by ~0.001 below 500 dbar, low at surface	use smaller station groupings
*46	S_{ctd} high by ~0.001 below 1000 dbar	use smaller station groupings
*47	S_{ctd} high by ~0.001 below 1000 dbar	use smaller station groupings
*48	S_{ctd} high by ~0.001 for whole profile	use smaller station groupings
*50	S_{ctd} high by ~0.001 below 1000 dbar	use smaller station groupings
*51	S_{ctd} high by ~0.001 for whole profile	use smaller station groupings
*52	S_{ctd} high by ~0.001 for 1000 to 4000 dbar	use smaller station groupings
*53	S_{ctd} high by ~0.001 below 2000 dbar	use smaller station groupings
*54	S_{ctd} low by ~0.001 below 2000 dbar	use smaller station groupings
*57	S_{ctd} low by ~0.001 for whole profile	use smaller station groupings
*58	S_{ctd} low by ~0.001 for whole profile	use smaller station groupings
61	1 to 5 dbar transient/despiking error in S_{ctd}	
63	1 to 10 dbar transient/despiking error in S_{ctd}	
*63	S_{ctd} low by ~0.001 for whole profile	use smaller station groupings
*64	S_{ctd} low by ~0.001 for whole profile	use smaller station groupings
*65	S_{ctd} low by ~0.001 for whole profile	use smaller station groupings
69	S_{ctd} high by ~0.001 below 1500 dbar	
70	S_{ctd} low by ~0.001 for whole profile	
73	S_{ctd} high by ~0.001 below 1500 dbar	
74	S_{ctd} high by ~0.001 below 2500 dbar (interesting S in top 120 m)	
75	S_{ctd} high by ~0.001 for whole profile	
*76	S_{ctd} high by ~0.001 below 1000 dbar	use smaller station grouping
*77	S_{ctd} high by ~0.001 below 2000 dbar	use smaller station grouping
*79	S_{ctd} high by ~0.001 below 1000 dbar	use smaller station grouping
*80	S_{ctd} high by ~0.001 for 2500 to 3500 dbar	use smaller station grouping
90	S_{ctd} low by ~0.001 for whole profile	
95	S_{ctd} high by ~0.001 for whole profile	

Table 3: (continued) Suspicious CTD salinity (S_{ctd}) data. * Indicates calibration improved by additional correction described in the text (i.e. using smaller station groupings).

station	comment	recommendation
96	S_{ctd} high by ~0.001 for top 3000 dbar	
*100	S_{ctd} high by ~0.001 for whole profile	use smaller station groupings
*101	S_{ctd} high by ~0.001 below 500 dbar	use smaller station groupings
*102	S_{ctd} high by ~0.001 below 500 dbar	use smaller station groupings
*103	S_{ctd} high by ~0.001 below 500 dbar	use smaller station groupings
*105	S_{ctd} high by ~0.001 below 500 dbar	use smaller station groupings
*111	S_{ctd} low by ~0.0008 for whole profile	use smaller station groupings
*112	S_{ctd} low by ~0.001 for whole profile	use smaller station groupings
*115	S_{ctd} low by ~0.001 for whole profile	use smaller station groupings
*119	S_{ctd} low by ~0.001 below 3500 dbar	use smaller station groupings
*120	S_{ctd} low by ~0.001 below 1200 dbar	use smaller station groupings
*121	S_{ctd} low by ~0.0015 below 2000 dbar	use smaller station groupings
124	S_{ctd} low by ~0.001 below 3000 dbar	
126	1 to 13 dbar transient/despiking error in S_{ctd}	
126	S_{ctd} low by ~0.001 for whole profile	
127	upcast CTDSAL values in .sea file bad below 2500 dbar (possible fouling)	flag as 3 in .sea file the CTDSAL values for samples 202 to 214
128	Sctd high by ~0.001 for 1000 to 5000 dbar	
*130	S_{ctd} high by ~0.001 for whole profile	use smaller station groupings
*132	S_{ctd} high by ~0.001 for 2000 to 5000 dbar	use smaller station groupings
133	S_{ctd} low by ~0.001 below 1500 dbar	
*138	S_{ctd} high by ~0.0008 below 2000 dbar	use smaller station groupings
*140	S_{ctd} high by ~0.001 for 1000 to 4000 dbar	use smaller station groupings
*143	S_{ctd} high by ~0.001 for 1500 to 4000 dbar	use smaller station groupings
144	S_{ctd} high by ~0.0015 below 2000 dbar	
146	1 to 6 dbar transient/despiking error in S_{ctd}	
*147	S_{ctd} high by ~0.0015 for whole profile	use smaller station groupings
*148	S_{ctd} high by ~0.001 below 500 dbar	use smaller station groupings
*154	S_{ctd} high by ~0.001 for 1200 to 3500 dbar	use smaller station groupings
*155	S_{ctd} low by ~0.001 below 1000 dbar	use smaller station groupings
*156	S_{ctd} low by ~0.001 below 1000 dbar	use smaller station groupings
*158	S_{ctd} high by ~0.001 below 500 dbar	use smaller station groupings
159	1 to 9 dbar transient/despiking error in S_{ctd}	
160	1 to 10 dbar transient/despiking error in S_{ctd}	
160	S_{ctd} high by ~0.001 for 500 to 4000 dbar, low below 4000 dbar	
168	Sctd high by ~0.001 for 800 to 4500 dbar	
173	S_{ctd} low by ~0.001 below 1000 dbar	

Table 4: Suspicious CTD oxygen data

station	comment	recommendation
8	high by ~2 µmol/kg below 500 dbar	calibrate station individually
10	high by ~2 µmol/kg below 1000 dbar	calibrate station individually
13	1 to 5 dbar transient/despiking error	
16	1 to 8 dbar transient/despiking error	
17	1 to 7 dbar transient/despiking error	
18	1 to 8 dbar transient/despiking error	
19	1 to 7 dbar transient/despiking error	
21	1 to 7 dbar transient/despiking error	
22 to 25	1 to 8 dbar transient/despiking error	
27	55 to 57 dbar spike	flag as 3 in .ctd file
29	1 to 8 dbar transient/despiking error	
32	1 to 11 dbar transient/despiking error	
40	1 to 8 dbar transient/despiking error	
43	1 to 10 dbar transient/despiking error	
44	1 to 11 dbar transient/despiking error	
45	1 to 12 dbar transient/despiking error	
46, 47	1 to 10 dbar transient/despiking error	
52	1 to 11 dbar transient/despiking error	
54	1 to 10 dbar transient/despiking error	
55	1 to 11 dbar transient/despiking error	
63	1 to 11 dbar transient/despiking error	
112	1 to 12 dbar transient/despiking error	
119	12 dbar spike	flag as 3 in .ctd file
135	high by ~2.5 µmol/kg for whole profile	calibrate station individually
148	1 to 5 dbar transient/despiking error	
152, 153	1 to 4 dbar transient/despiking error	
155	1 to 4 dbar transient/despiking error	
161	1 to 11 dbar transient/despiking error	
164	1 to 3 dbar transient/despiking error	
165	1 to 6 dbar transient/despiking error	

Table 5: Density inversions < -0.003 kg/m^3/dbar, and quality flag for salinity in .ctd file for the pressure bin.

Stn	Pres. (dbar)	Density gradient	Sal. flag	Stn	Pres. (dbar)	Density gradient	Sal. flag	Stn	Pres. (dbar)	Density gradient	Sal. flag
8	7	-0.0057	7	106	8	-0.0163	7	155	10	-0.0048	6
8	8	-0.0032	7	107	2	-0.0059	7	155	11	-0.0048	2
10	7	-0.0058	7	107	3	-0.0046	7	157	5	-0.0099	7
20	4	-0.0047	7	107	9	-0.0190	7	159	6	-0.0052	7
22	6	-0.0061	7	107	12	-0.0099	6	162	5	-0.0036	7
40	105	-0.0031	6	107	13	-0.0099	6	162	12	-0.0030	6
40	106	-0.0031	6	107	14	-0.0100	2	162	13	-0.0030	6
40	107	-0.0032	2	108	5	-0.0108	7	162	14	-0.0030	2
45	9	-0.0102	7	109	2	-0.0193	7	165	4	-0.0050	7
49	8	-0.0181	7	110	2	-0.0037	7	167	4	-0.0125	7
54	8	-0.0044	7	111	2	-0.0094	7	169	3	-0.0053	7
57	2	-0.0041	7	112	2	-0.0122	7	169	5	-0.0034	7
60	7	-0.0114	7	113	3	-0.0037	7	170	2	-0.0035	7
64	8	-0.0054	7	113	4	-0.0034	7	174	4	-0.0036	7
64	9	-0.0040	7	117	3	-0.0046	7	176	2	-0.0130	7
68	2	-0.0052	7	117	7	-0.0059	7	176	5	-0.0033	7
69	11	-0.0061	7	120	2	-0.0032	7	177	3	-0.0049	7
69	12	-0.0030	6	121	2	-0.0040	7	177	4	-0.0035	7
69	13	-0.0030	6	124	3	-0.0135	7	180	2	-0.0108	7
69	14	-0.0031	2	124	4	-0.0047	7	181	2	-0.0073	7
70	4	-0.0058	7	125	2	-0.0042	7	182	2	-0.0034	7
70	6	-0.0046	7	126	2	-0.0055	7	182	3	-0.0078	7
71	7	-0.0054	7	131	7	-0.0033	7				
78	5	-0.0094	7	131	11	-0.0053	7				
78	8	-0.0080	7	132	2	-0.0034	7				
78	9	-0.0254	7	134	4	-0.0030	7				
82	3	-0.0032	7	134	7	-0.0033	7				
83	8	-0.0089	7	135	2	-0.0063	7				
84	2	-0.0042	7	136	2	-0.0125	7				
85	5	-0.0082	7	139	9	-0.0103	7				
86	2	-0.0031	7	140	6	-0.0134	7				
87	2	-0.0036	7	143	2	-0.0073	7				
88	5	-0.0173	7	143	3	-0.0067	7				
89	4	-0.0063	7	143	4	-0.0038	7				
89	5	-0.0075	7	144	2	-0.0066	7				
90	5	-0.0071	7	148	2	-0.0084	7				
90	9	-0.0151	7	152	3	-0.0047	7				
91	4	-0.0057	7	153	2	-0.0136	7				
99	3	-0.0042	7	154	2	-0.0054	7				
101	4	-0.0033	7	154	4	-0.0059	7				
101	8	-0.0046	7	155	6	-0.0047	6				
102	7	-0.0040	7	155	7	-0.0048	6				
105	4	-0.0054	7	155	8	-0.0048	6				
106	4	-0.0038	7	155	9	-0.0048	6				

Table 6: Summary of flag changes recommended in .ctd (i.e. .wct) files. Note that for all cases shallower than 15 dbar, all data above the reflagged values was already flagged as 7 (i.e. despiked) - 7 flags were not changed.

station	parameter	pressure	old flag	new flag
45	T	9	2	3
49	T	8 to 11	2	3
61	S	5	2	3
63	S	6 to 10	2	3
126	S	11	2	3
126	S	12 to 13	6	3
146	S	6	2	3
159	S	8 to 9	2	3
160	S	11	6	3
13	O	5	2	3
19	O	7	2	3
25	O	8	2	3
27	O	55 to 57	2	3
52	O	11	2	3
63	O	11	2	3
119	O	12	2	3

Figure 1

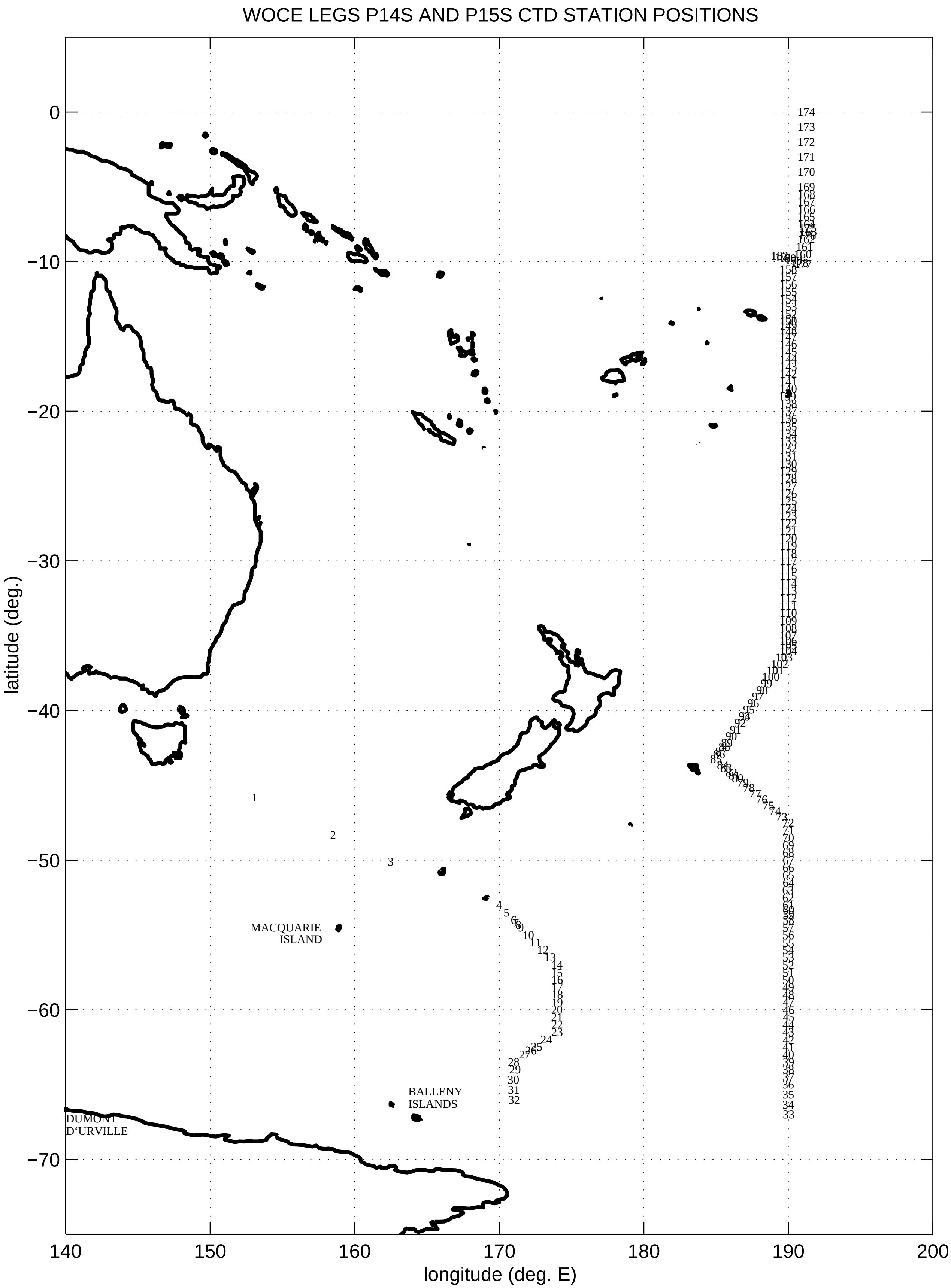

WOCE LEGS P14S AND P15S CTD STATION POSITIONS
latitude (deg.)
longitude (deg. E)
MACQUARIE ISLAND
BALLENY ISLANDS
DUMONT D'URVILLE

Figure 2

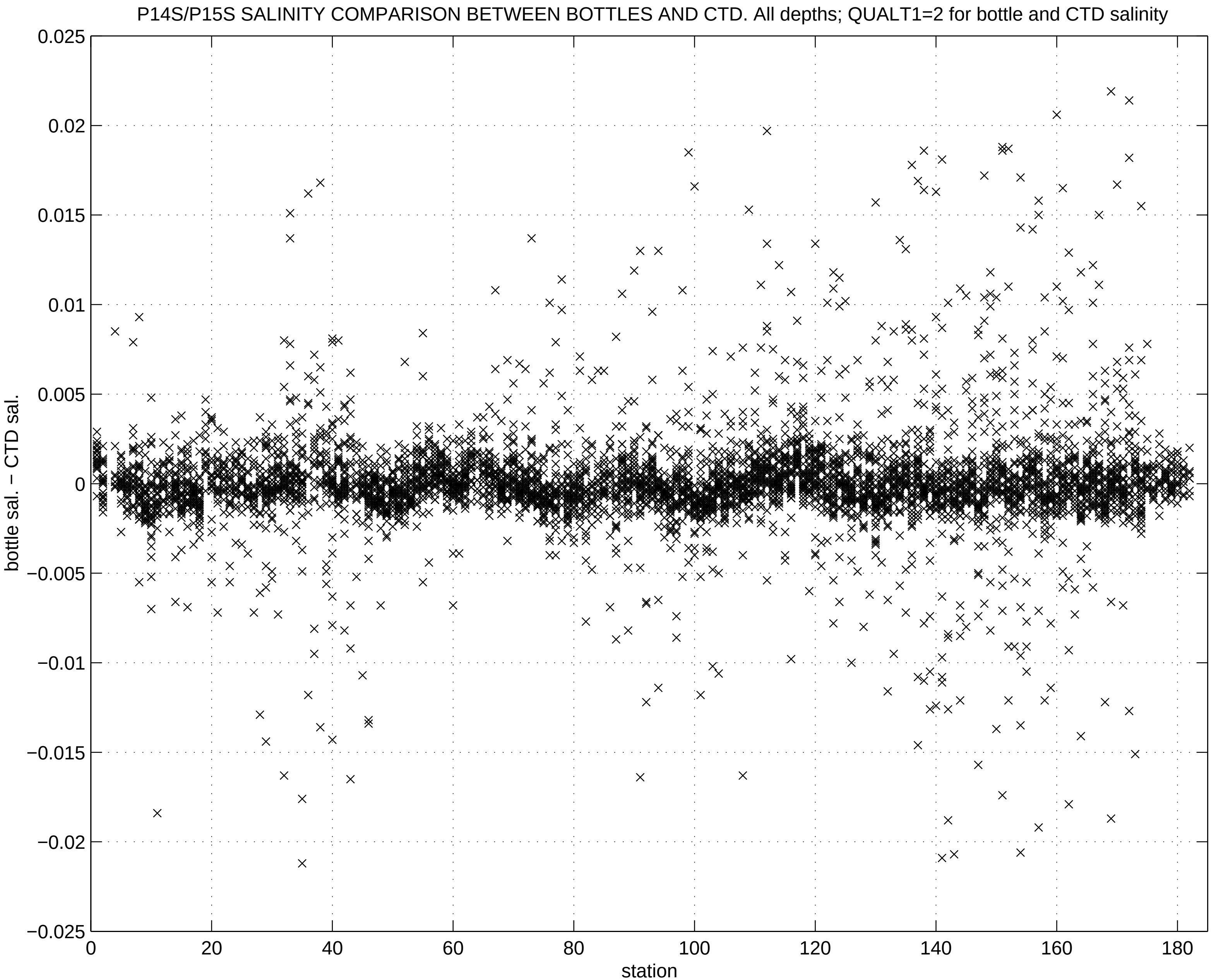
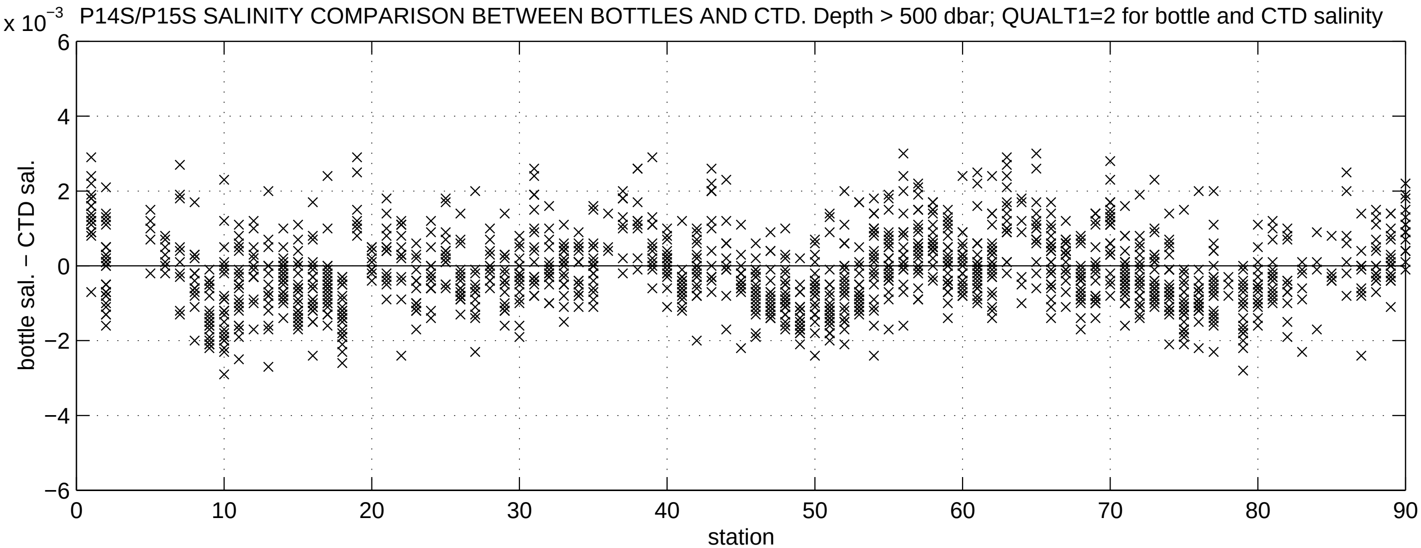
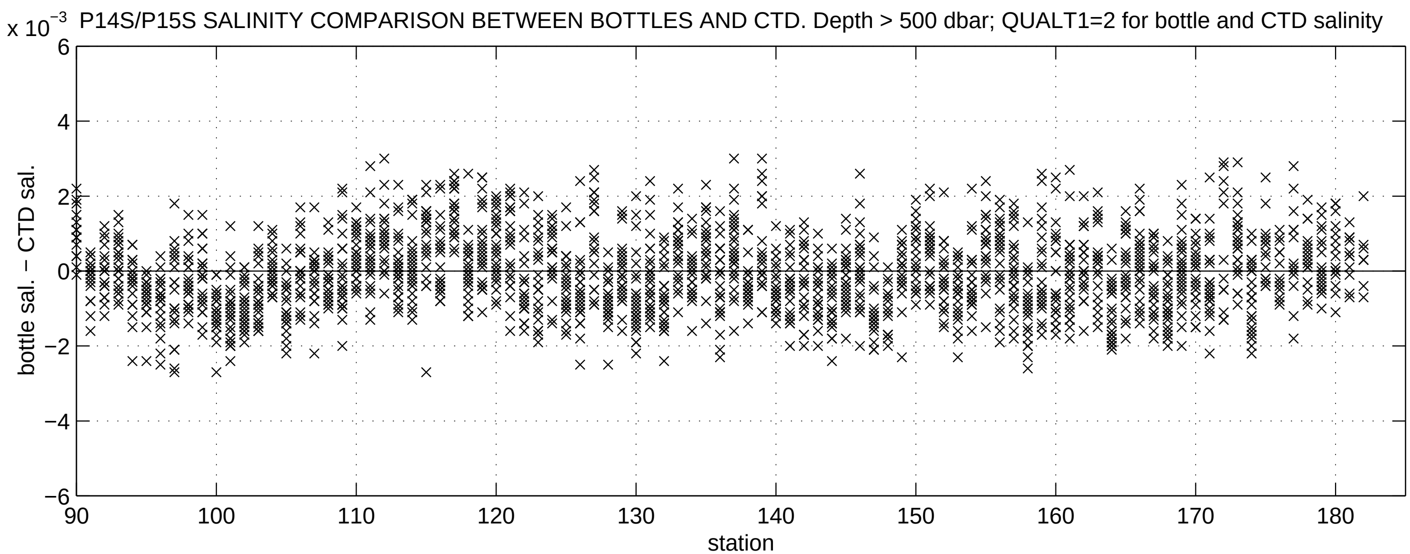

P14S/P15S SALINITY COMPARISON BETWEEN BOTTLES AND CTD. All depths; QUALT1=2 for bottle and CTD salinity
0.025
0.02
0.015
0.01
0.005
0
−0.005
−0.01
−0.015
−0.02
−0.025
bottle sal. − CTD sal.
0
20
40
60
80
100
120
140
160
180
station

Figure 3



P14S/P15S SALINITY COMPARISON BETWEEN BOTTLES AND CTD. Depth > 500 dbar; QUALT1=2 for bottle and CTD salinity
x 10^-3
6
4
2
0
−2
−4
−6
bottle sal. − CTD sal.
0
10
20
30
40
50
60
70
80
90
station



P14S/P15S SALINITY COMPARISON BETWEEN BOTTLES AND CTD. Depth > 500 dbar; QUALT1=2 for bottle and CTD salinity
x 10^-3
6
4
2
0
−2
−4
−6
bottle sal. − CTD sal.
90
100
110
120
130
140
150
160
170
180
station

Figure 4: Corrected salinities

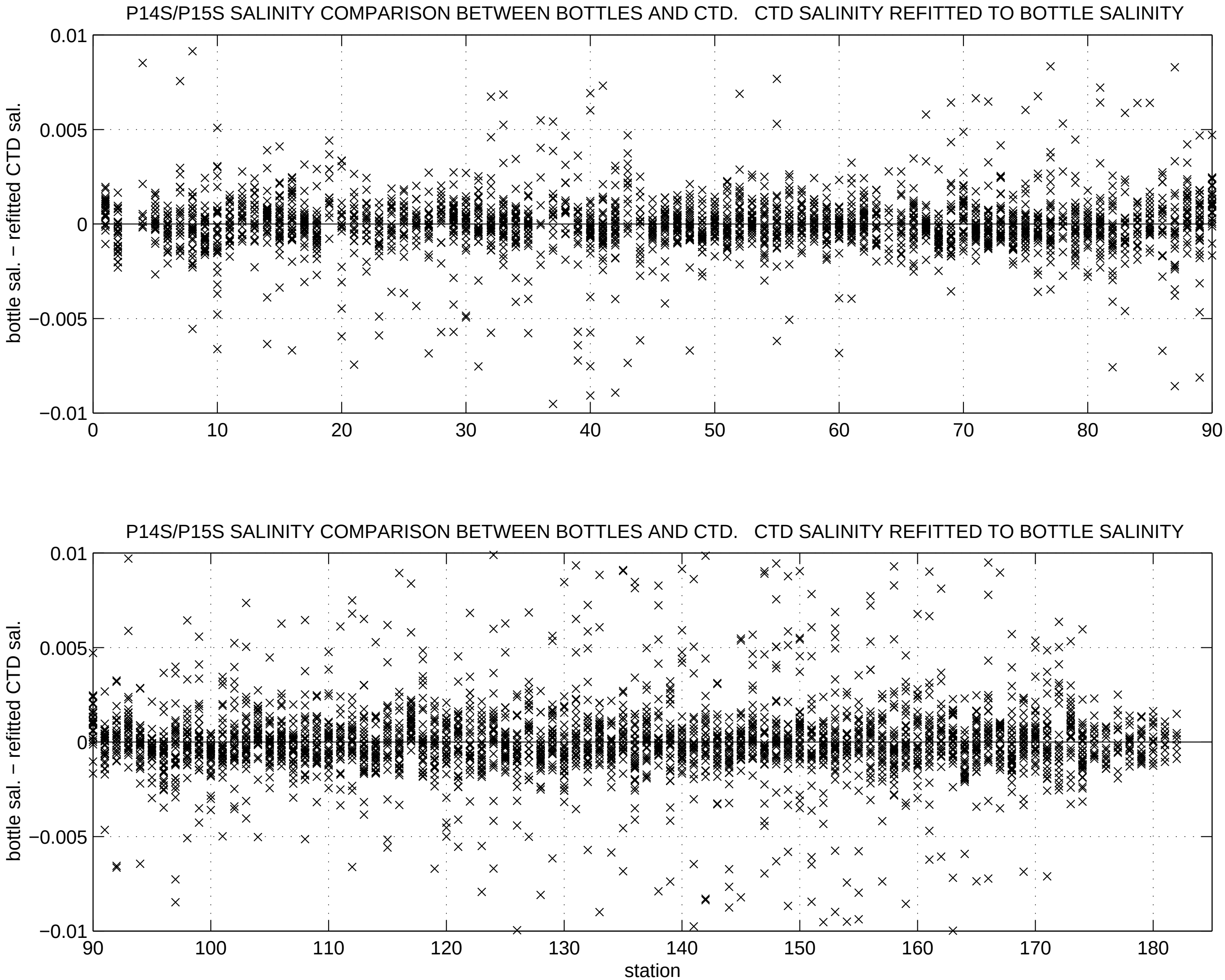
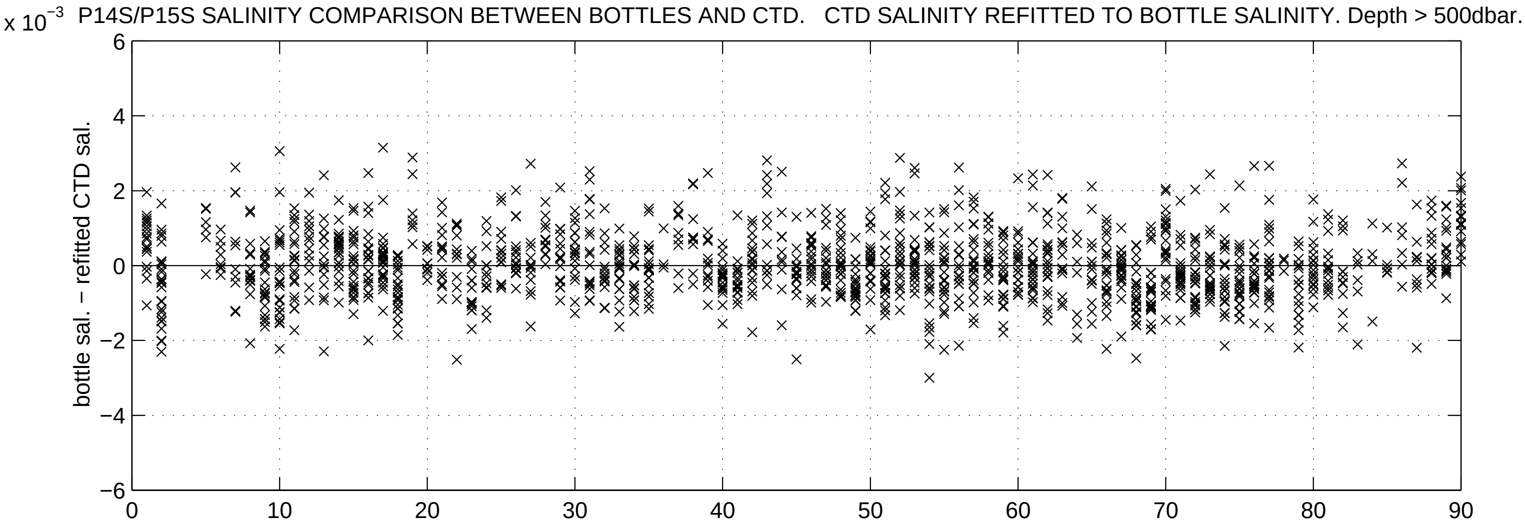


Figure 5: Corrected salinities



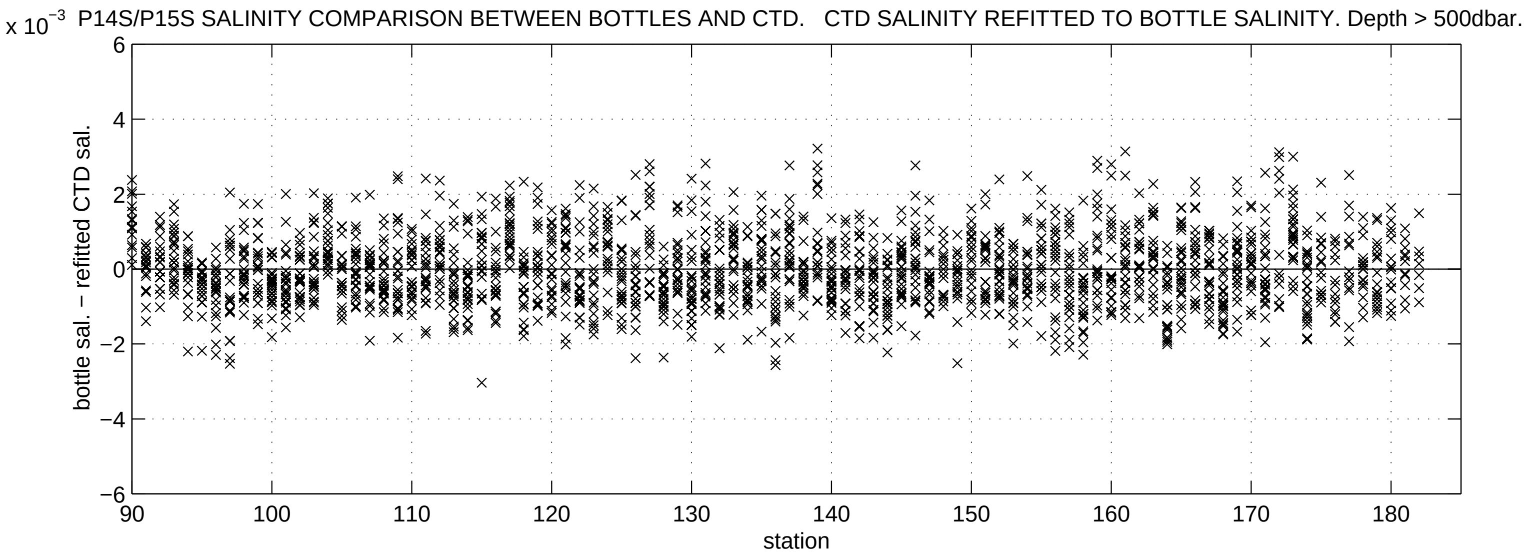


Figure 6

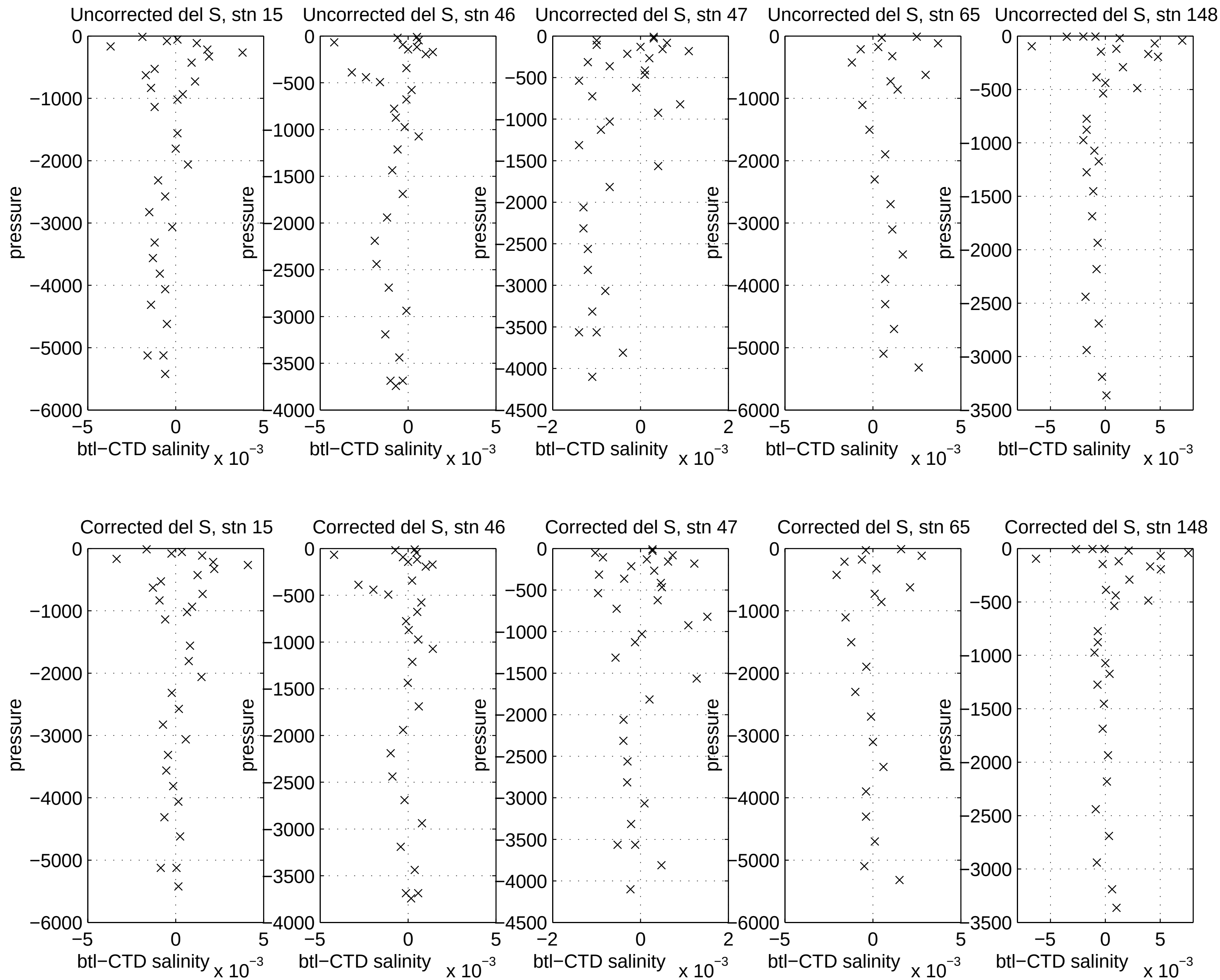
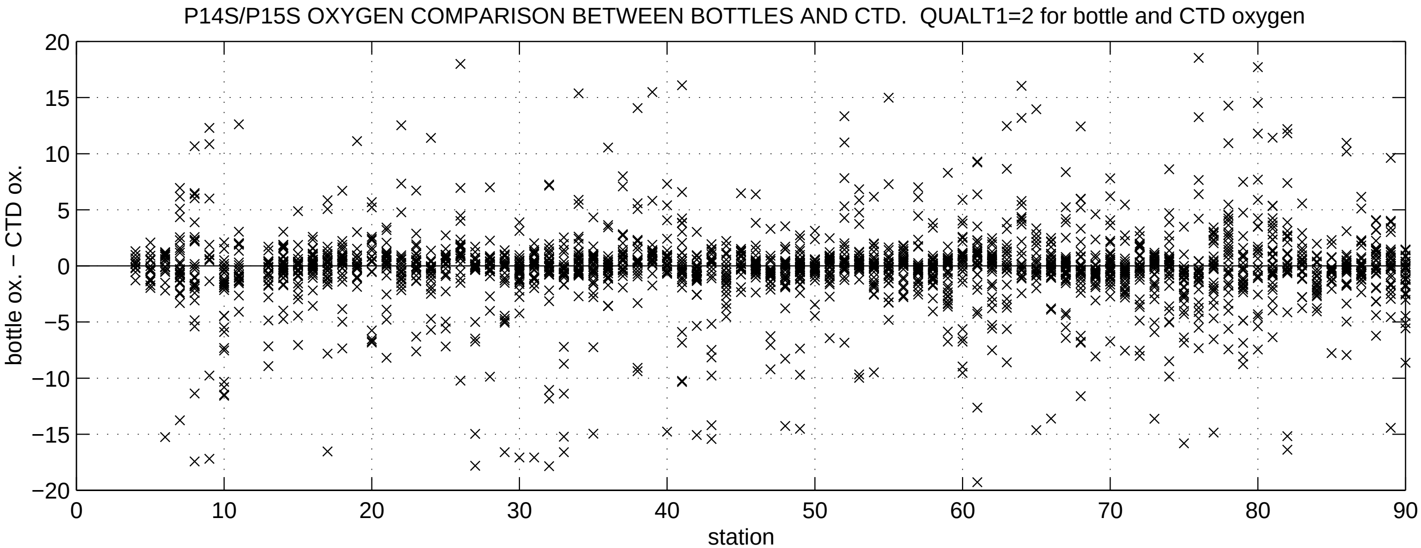

Uncorrected del S, stn 15
Uncorrected del S, stn 46
Uncorrected del S, stn 47
Uncorrected del S, stn 65
Uncorrected del S, stn 148
Corrected del S, stn 15
Corrected del S, stn 46
Corrected del S, stn 47
Corrected del S, stn 65
Corrected del S, stn 148
pressure
btl−CTD salinity
x 10−3

Figure 7


P14S/P15S OXYGEN COMPARISON BETWEEN BOTTLES AND CTD. QUALT1=2 for bottle and CTD oxygen
bottle ox. − CTD ox.
station
20
15
10
5
0
−5
−10
−15
−20
0
10
20
30
40
50
60
70
80
90

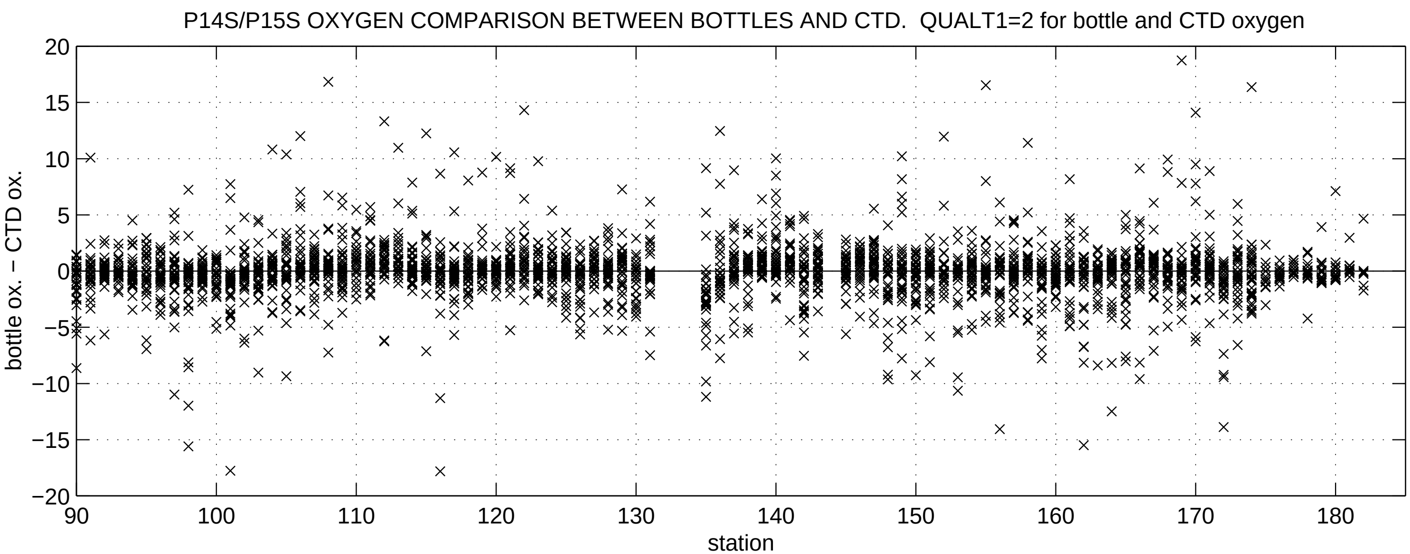

P14S/P15S OXYGEN COMPARISON BETWEEN BOTTLES AND CTD. QUALT1=2 for bottle and CTD oxygen
bottle ox. − CTD ox.
station
20
15
10
5
0
−5
−10
−15
−20
90
100
110
120
130
140
150
160
170
180

Figure 8

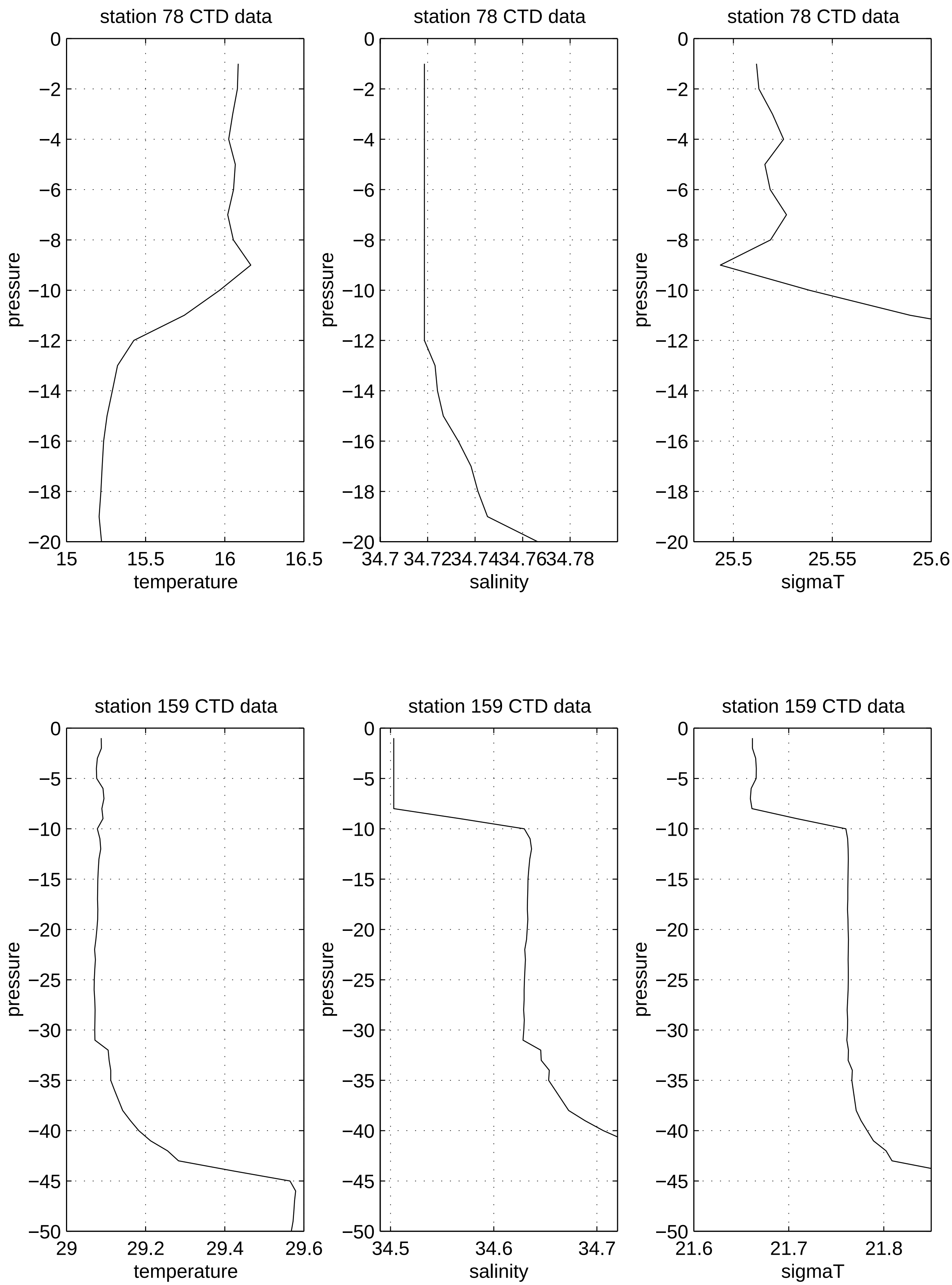
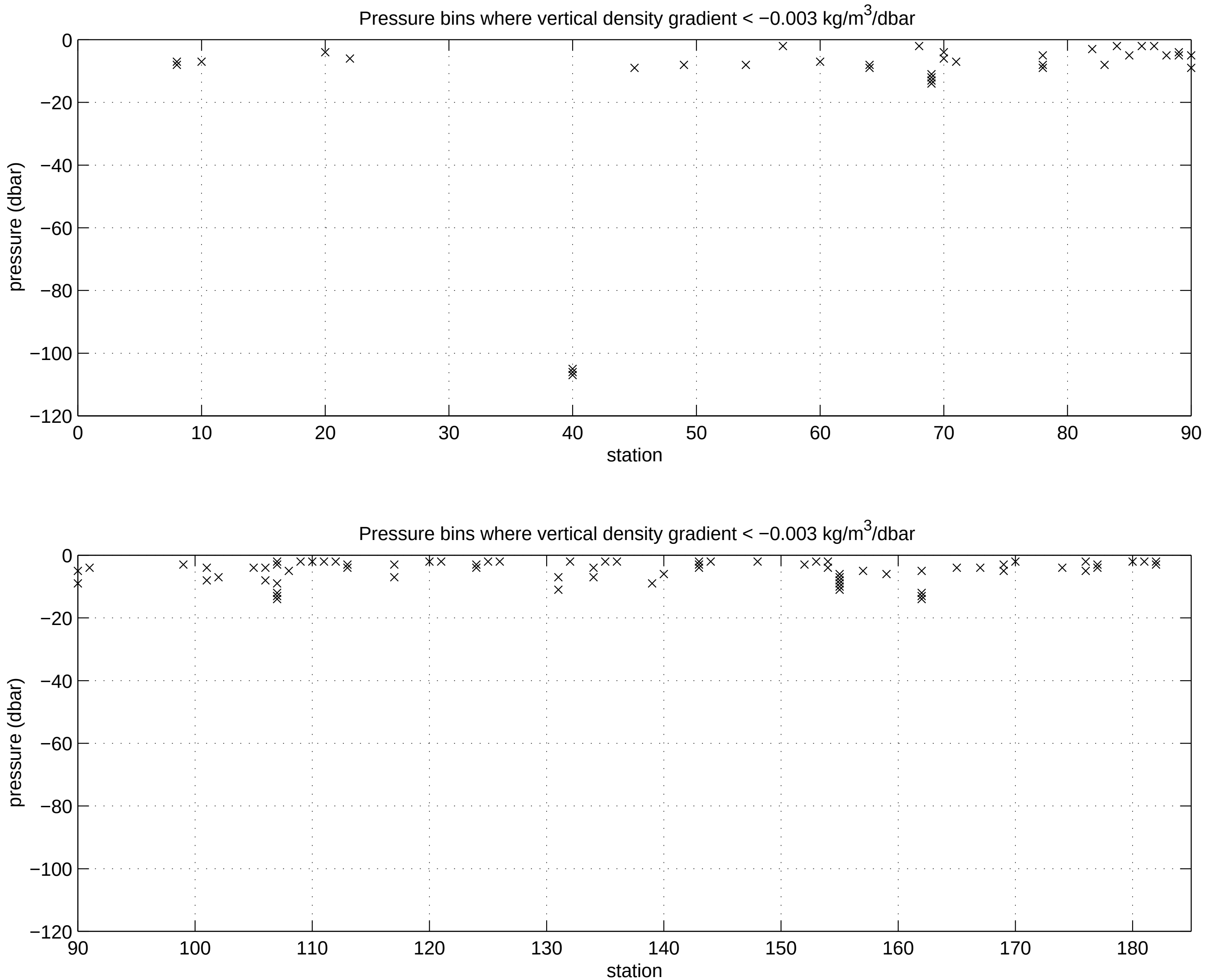

station 78 CTD data
pressure
temperature
0
−2
−4
−6
−8
−10
−12
−14
−16
−18
−20
15
15.5
16
16.5
station 78 CTD data
pressure
salinity
34.7
34.72
34.74
34.76
34.78
station 78 CTD data
pressure
sigmaT
25.5
25.55
25.6
station 159 CTD data
pressure
temperature
0
−5
−10
−15
−20
−25
−30
−35
−40
−45
−50
29
29.2
29.4
29.6
station 159 CTD data
pressure
salinity
34.5
34.6
34.7
station 159 CTD data
pressure
sigmaT
21.6
21.7
21.8

Figure 9



Pressure bins where vertical density gradient < −0.003 kg/m3/dbar
pressure (dbar)
0
−20
−40
−60
−80
−100
−120
0
10
20
30
40
50
60
70
80
90
station
Pressure bins where vertical density gradient < −0.003 kg/m3/dbar
pressure (dbar)
0
−20
−40
−60
−80
−100
−120
90
100
110
120
130
140
150
160
170
180
station

Figure 10: P15S and P15N comparison

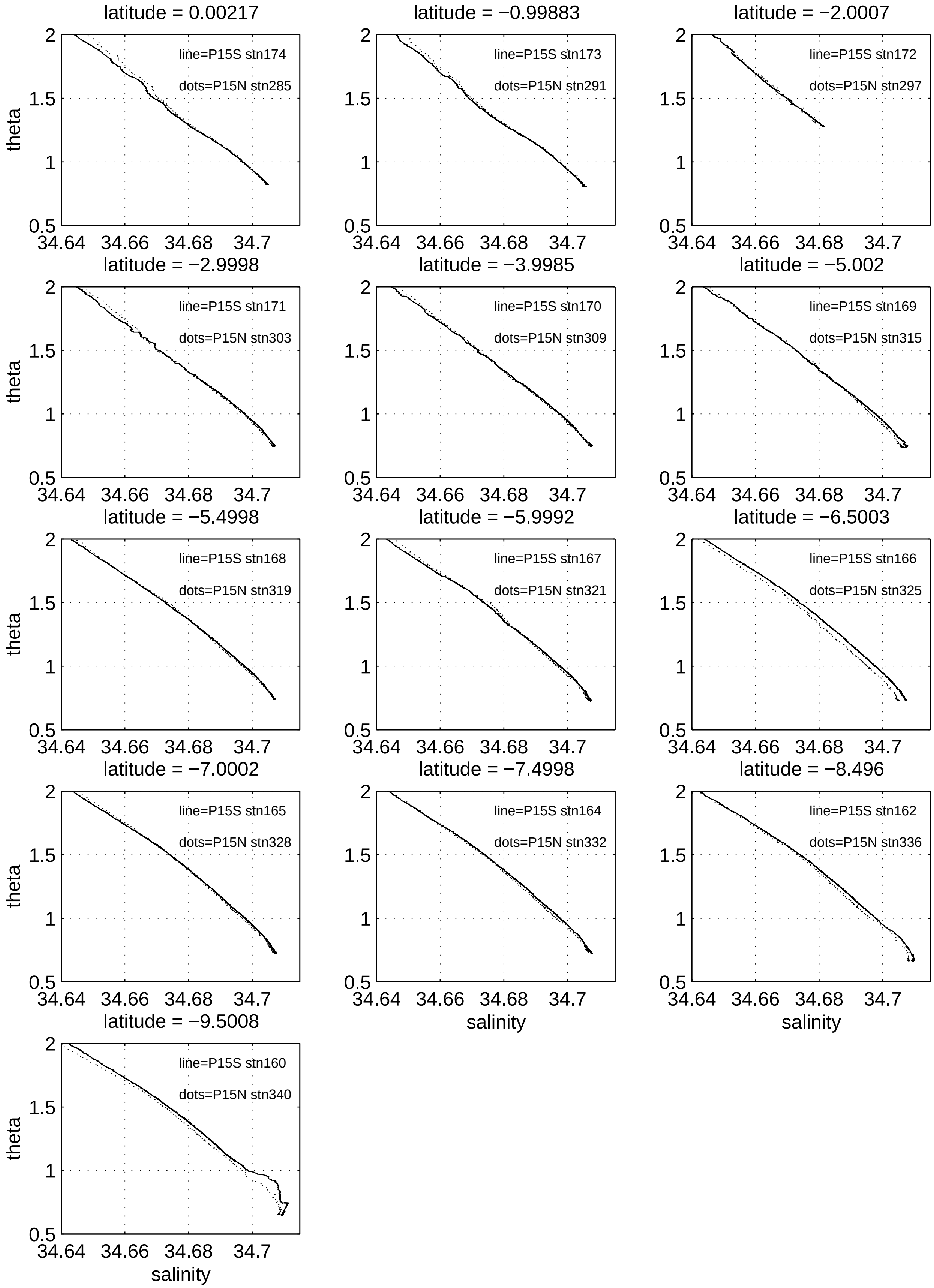


Figure 11: P15S and P31 comparison

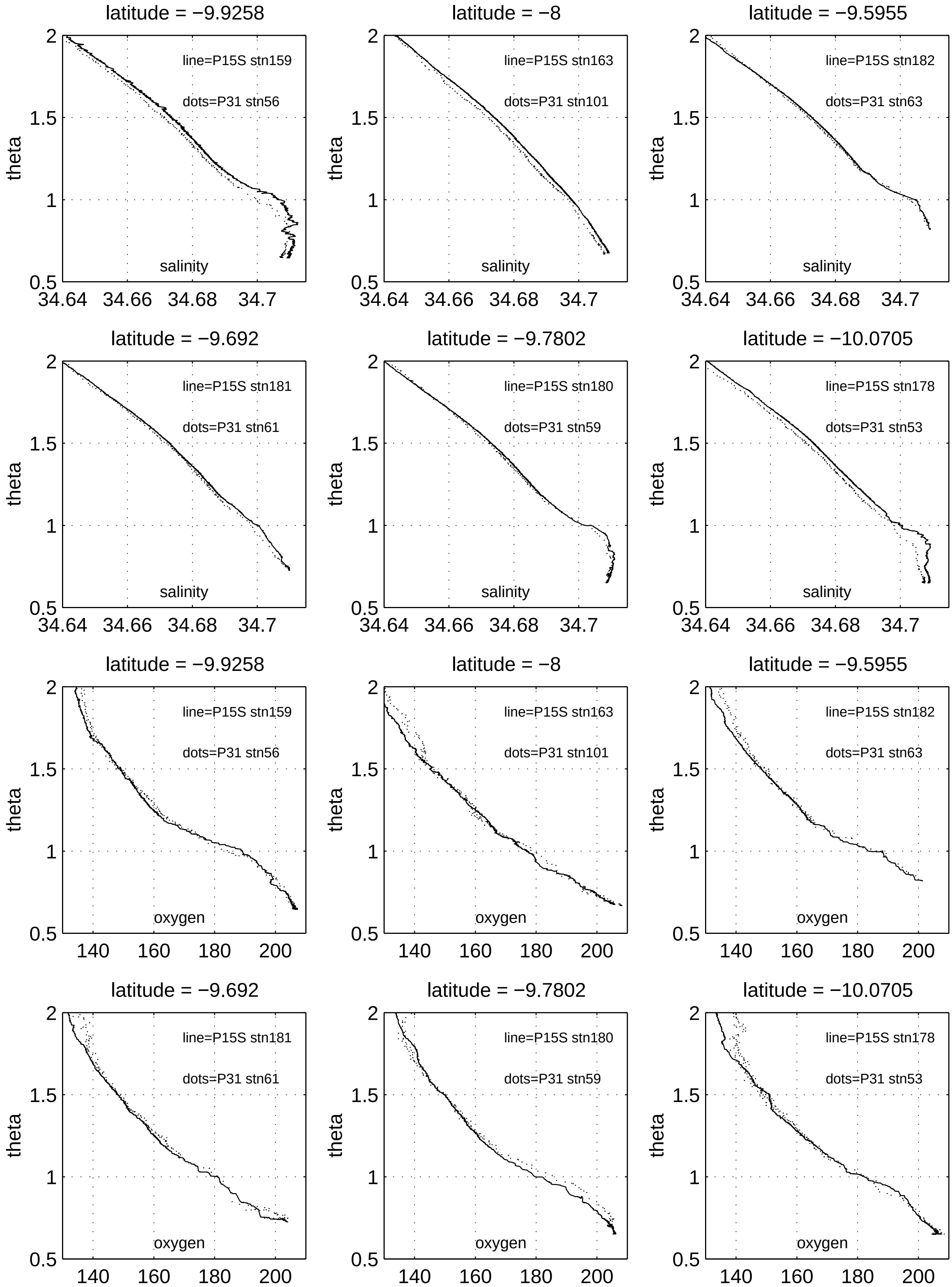
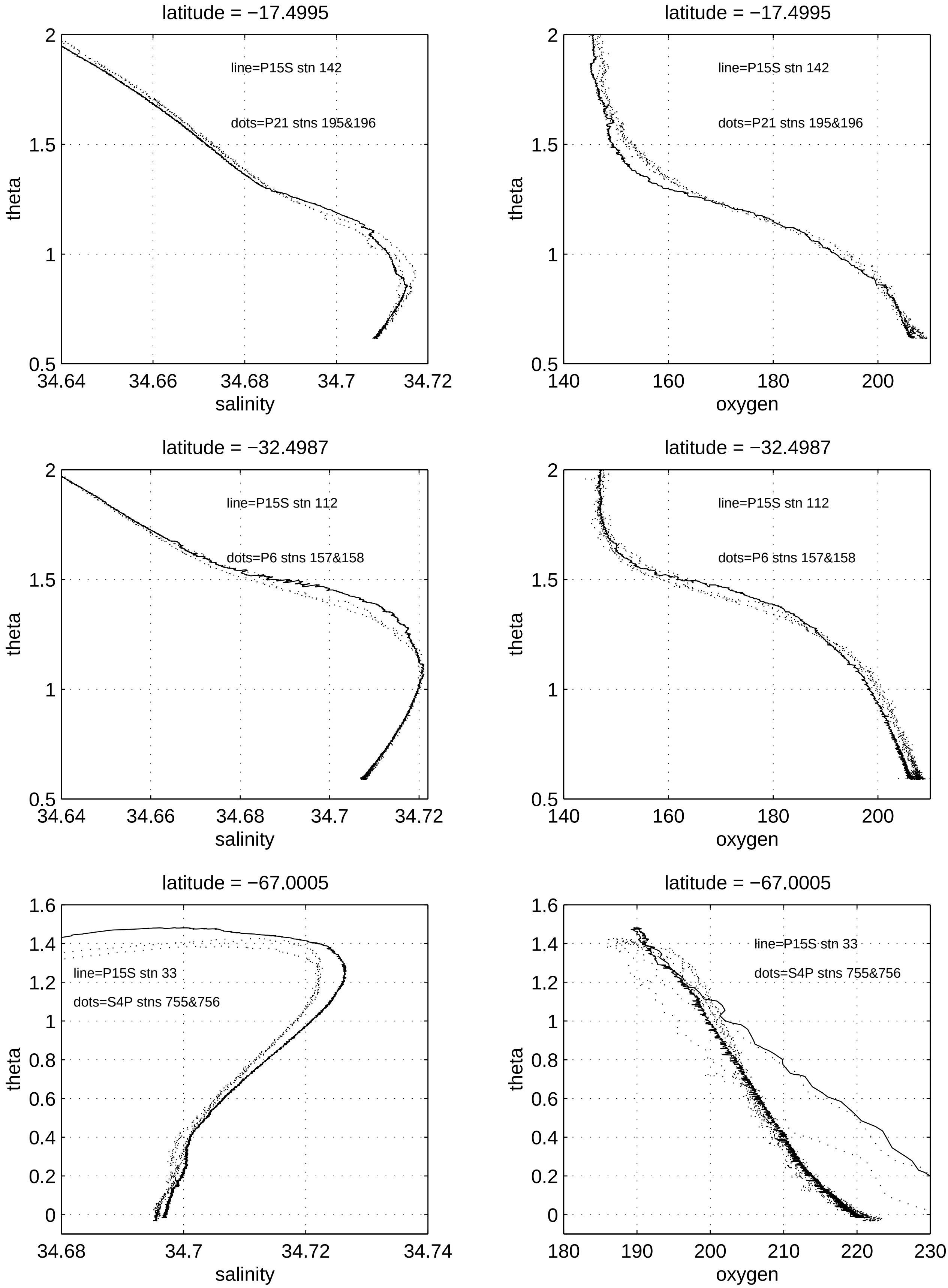


Figure 12: Comparison of P15S with P21, P06 and S04P



D.3. Response to CTD Data DQE

(Kristy McTaggart and Greg Johnson)

We considered each of the suggestions and the following is an itemized explanation of what we did or didn't change in our data files, as well as answers to DQE's questions.

Station Summary File (.sum)

Stations 21 and 77 should be listed as cast 1. The .sum and .ctd files should be corrected. We've corrected our files here.

The uncorrected sounder depth at the bottom of the cast for stations 44 and 55 may appear erroneous. However, these are not typos. They are the values calculated from the ship's PDR during acquisition. The bottom at station 44 in particular was noted to be strongly sloping. We did not change these values in our files.

The PDR sound speed used for sounder readings was 1500 m/s. The readings were not corrected for transducer depth below the waterline. The depth of the transducer would've been about 5.5 +/- 0.6 m. We would prefer to use the PDR depths as listed and correct them using Carter's tables so that they serve as independent measurements and can be used as a check on CTD pressure.

Salinity

Scatter Of Salinity Residuals

There is an incompatibility between the General Oceanics rosette sampler and the Sea-Bird 911plus CTD system that generates a spike in the data stream at the moment a bottle is confirmed as tripped. Because of this, upcast CTD burst data had to be averaged prior to the bottle confirm bit. Two-second averages were chosen over a longer interval because the CTD operators did not always let the package sit at bottle depth for at least 10 seconds before firing the rosette. Hence no changes were made.

Biasing Of CTD Salinity Data For Individual Stations

Of course one can seemingly make a (very slight) improvement in the CTD-bottle residual statistics by allowing more degrees of freedom in the fit as the DQE has suggested (that is, breaking up the fit into small station groupings). One could get the best statistics by individually fitting each station to its bottles, but most experts would argue that this would be a bad choice, because one would not be taking advantage of the CTD calibration as a way to average out station-to-station bottle salinity noise.

We believe that the SBE-9/11 CTD conductivity slope drifts gradually, and is actually more stable than the day-to-day fluctuations in the autosalinometer salinities owing to small temperature drifts in the laboratory and the fact that severe budgetary constraints on these cruises forced us to economize even on such things as standard sea water. We suspect that the "biasing of the CTD salinity data" mentioned in the DQE evaluations is actually noise in the bottle data. Somewhat suspicious is that the station groupings recommended by the DQE of the correct size (most often 3-5 stations per group) that they could easily be owing to daily drift problems in the autosalinometer. For our original calibrations we deliberately chose to model the conductivity slope adjustments of the entire data sets for P14S/P15S and P18 using 4th-order polynomial functions of station number to average out bottle salinity noise. We did this because we saw no obvious jumps in the CTD calibration for either cruise, just gradual drifts.

Statistical support for our philosophy over that of the DQE is given by the following exercise: The 2°C potential isotherm is well within the oldest Pacific Deep Water, and has some of the tightest θS relationships in the Pacific Ocean (and probably the world). For both P18 and P14S/P15S, we looked at the absolute values of station-to-station changes in CTD salinity on θ=2.0°C (Figure 1) for our original calibration, creating a histogram of station-to-station differences for each cruise in 0.001 bins. We then applied the DQE's suggested ad-hoc calibrations for smaller station groupings to the data and conducted the same analysis. When the histograms are differenced (Figure 2), one can see that the θS relations at 2°C after the DQE's corrections are noisier for both cruises. For P18, after the DQE's suggested correction there are four less station pairs in the 0.000 difference bin and one less in the 0.001 difference bin whereas there are three more in the 0.002 difference bin and two more in the 0.003 difference bin. For P15S/P15S there are four less stations in the 0.000 difference bin after the DQE's suggested correction, with one more in the 0.001 difference bin and three more in the 0.002 difference bin. Since the DQE's "corrections" actually introduce more noise in the CTD θS relation at 2°C than our original calibration, we decline application of them. The small groups do not improve the calibration, they degrade, perhaps by introducing autosalinometer drift noise.

Regarding suspicious CTD salinity data listed in Table 3, no changes were made to any profile data (see above) nor flags associated with "transient/despiking errors". As for CTDSAL values in the .sea file for station 127, we agree that they should be flagged as 3 for samples 202 to 214. Also, BOTSAL flags for samples 209, 210, 213, and 214 should then be changed to 2.

Problem Salinity Bottle Data

Excluding stations 19, 49, 117, and 164 bottle salinity values from the calibration of this data set as a whole would not significantly change the fit as we have done it, thus we didn't make this adjustment.

Oxygen

Quality flags should be amended as suggested in Table 4. However, stations 8, 10, and 135 will not be recalibrated individually as they are among the first casts with a new sensor module. As a rule, the first few casts with a new module are problematic, and this cruise was no exception.

Temperature

The very spikey temperature structure between 100 and 300 dbar at station 43 is also seen in salinity and has been identified as Antarctic Intermediate Water interleaving at the front. It is also seen at adjacent stations 42 and 44. Nothing should be done to this profile.

Temperature spikes listed were examined but not changed. Neither were their flags changed.

Despiking and Interpolation

Interpolated temperature and salinity data are the result of processing programs and not instrument or electronic problems. In program DESPIKE salinity profiles are viewed and interactively despiked using linear interpolation. Conductivity, θ, and σ-θ are recomputed for the interpolated records. Only the salinity quality flag is amended to 6. In program DELOOP Brunt-Vaisala Frequency squared (N2) is computed at the mid depths and bracketed between two vectors, one padded with zeros at the surface and one padded with zeros at depth. If the first and second points of a -N2 fail the criteria (<=-1e-05), then temperature and conductivity are linearly interpolated and salinity, θ, and σ-θ are recomputed. The quantity of interpolated points is large because we were working with a large package off the stern of the ship, often in the Southern Ocean. Hence, there was a lot of wake problems.

As for the filled surface records flagged as 7, we maintain that this is more useful than leaving flagged bad or questionable data or removing the data entirely. It should be noted in the documentation that all data in the top 15 dbar with a flag of 7 should be regarded as questionable.

Density Inversions

Density inversions listed in Table 5 were examined and salinity quality flags were changed to '3' for the following records.

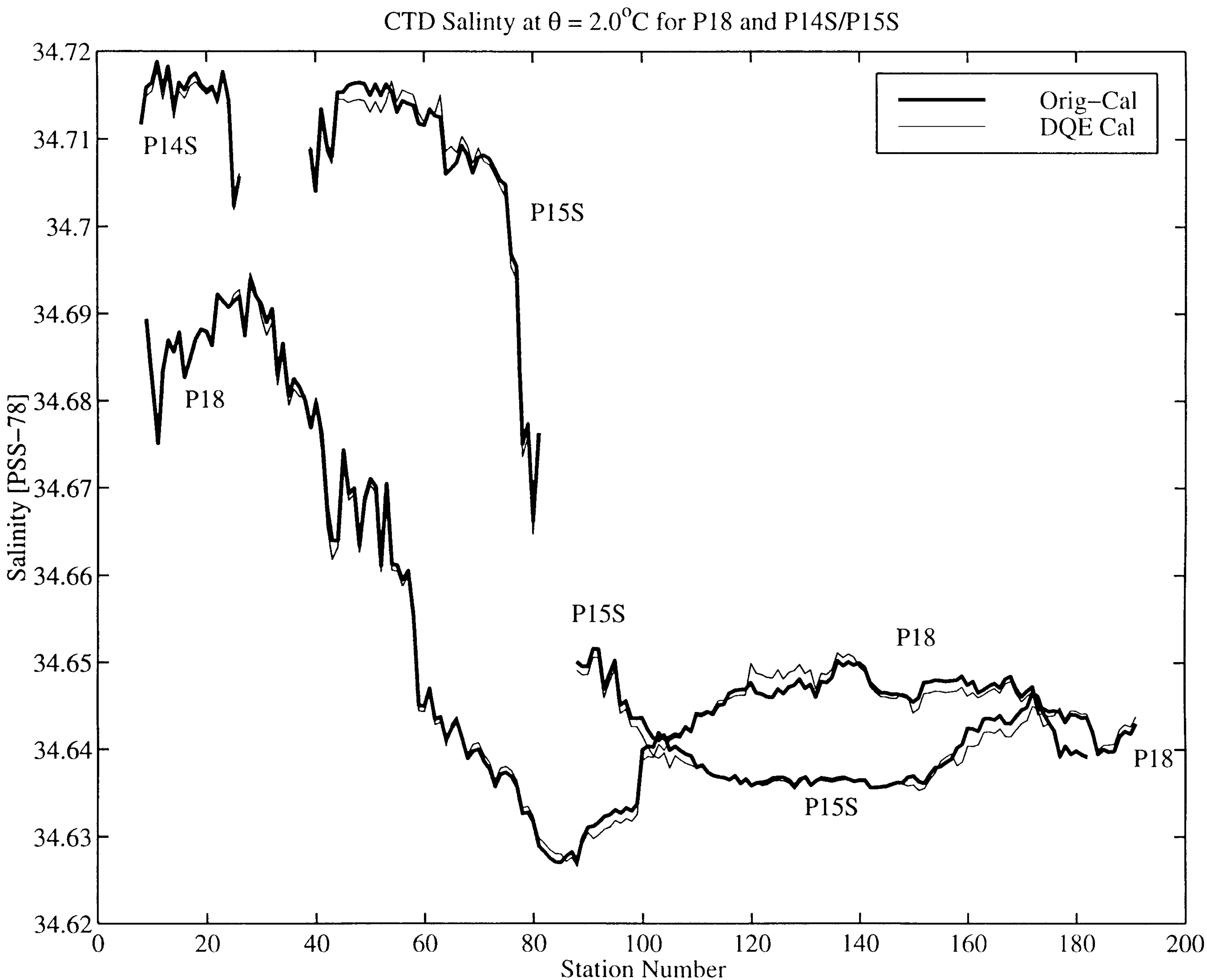
Documentation

Again, the PDR sound speed was 1500 m/s, and the readings have not been corrected for transducer depth (5.5 +/- 0.6 m) below the waterline.

The criteria used for despiking are explained above under DESPIKING AND INTERPOLATION.

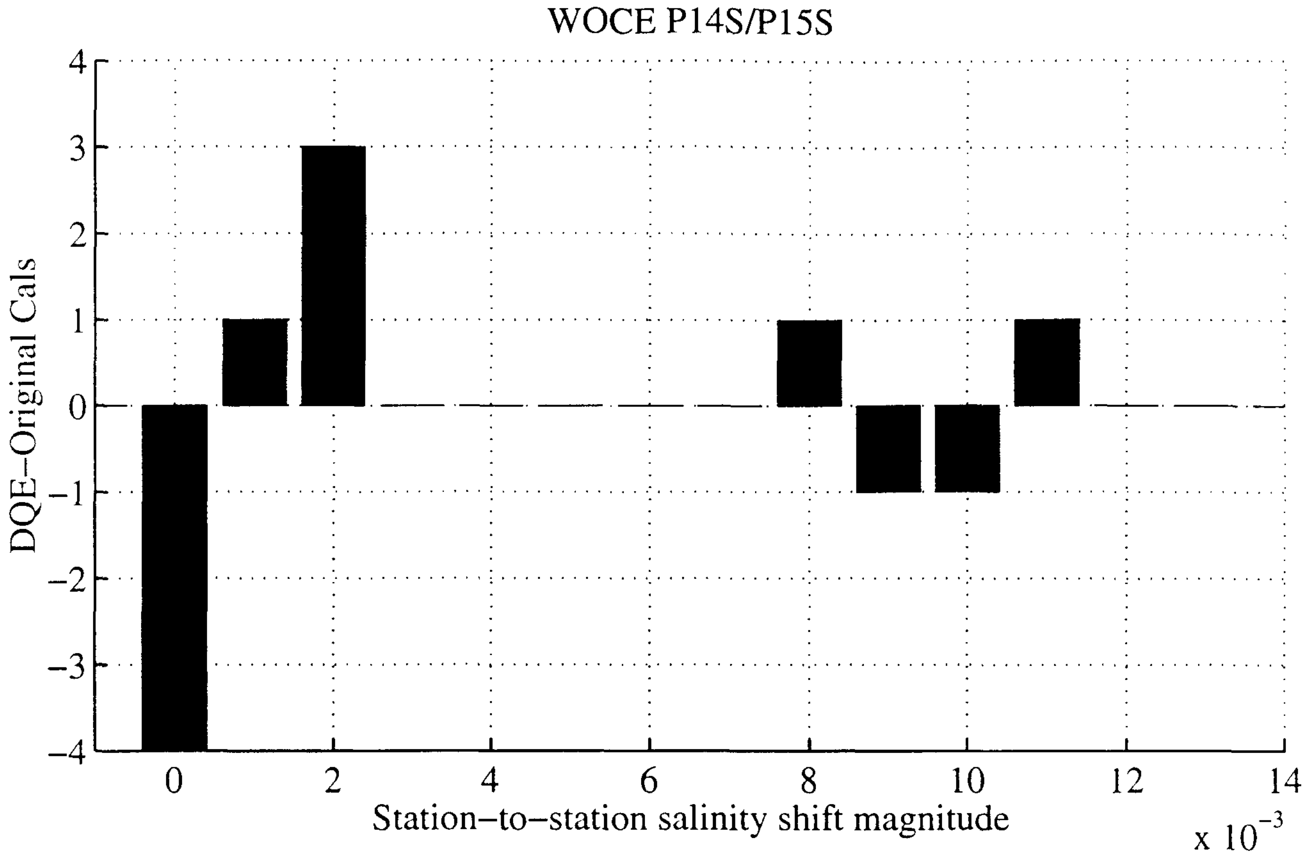
Stn	Pressure	Stn	Pressure	Stn	Pressure	Stn	Pressure
8	5-7	85	4	113	1-3	152	1-2
10	1-7	86	1	117	1-6	153	1-2
20	1-3	87	1	120	1	154	1-3
22	1-5	88	3,4	121	1	155	1-15
45	1-8	89	3,4	124	1-3	157	1-4
49	1-7	90	4,8	125	1-3	159	1-6
54	7	91	1-4	126	1-13	160	1-12
57	1	99	1-2	131	3,5,6,10	162	1-13
60	5-6	101	1,3,7	132	1-9	165	1-3
64	7-8	102	6	134	1-3,6	167	1-3
68	1	105	1-3	135	1	169	1-7
69	1-14	107	1-2,8,11-13	136	1	170	1-3
70	3,5	106	1-3,6,7	139	8	174	1-3
71	6	108	4	140	4,5	176	1-4
78	1-9	109	1	143	1-3	177	1-3
82	1-4	110	1	144	1	180	1-3
83	7	111	1	146	1-6	181	1
84	1-2	112	1	148	1-3	182	1-2

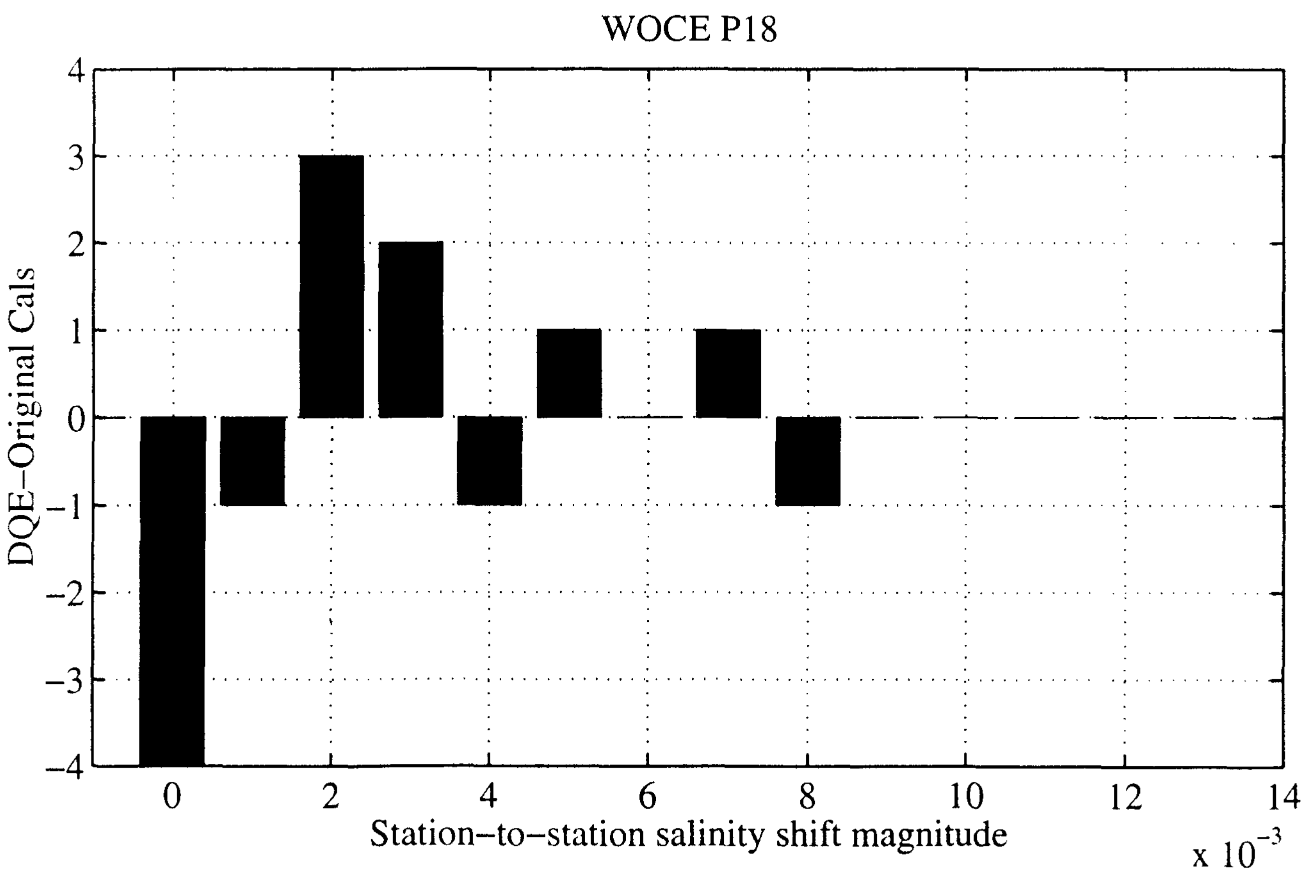
Figure 1



CTD Salinty at θ = 2.0°C for P18 and P14S/P15S
Orig−Cal
DQE Cal
P14S
P15S
P18
P15S
P18
P15S
P18
Salinity [PSS−78]
34.72
34.71
34.7
34.69
34.68
34.67
34.66
34.65
34.64
34.63
34.62
0
20
40
60
80
100
120
140
160
180
200
Station Number

Figure 2


WOCE P14S/P15S
DQE–Original Cals
Station–to–station salinity shift magnitude
x 10^-3
4
3
2
1
0
–1
–2
–3
–4
0
2
4
6
8
10
12
14


WOCE P18
DQE–Original Cals
Station–to–station salinity shift magnitude
x 10^-3
4
3
2
1
0
–1
–2
–3
–4
0
2
4
6
8
10
12
14

D.3. Final CFC Data DQE

(David Wisegarver - Dec 2000)

During the initial DQE review of the CFC data, a small number of samples were given QUALT2 flags which differed from the initial QUALT1 flags assigned by the PI. After discussion, the PI concurred with the DQE assigned flags and updated the QUAL1 flags for these samples.

The CFC concentrations have been adjusted to the SIO98 calibration Scale (Prinn et al. 2000) so that all of the Pacific WOCE CFC data will be on a common calibration scale.

For further information, comments or questions, please, contact the CFC PI for this section

J. Bullister: johnb@pmel.noaa.gov

or

David Wisegarver: wise@pmel.noaa.gov

Additional information on WOCE CFC synthesis may be available at:

http://www.pmel.noaa.gov/cfc.

Prinn, R. G., R. F. Weiss, P. J. Fraser, P. G. Simmonds, D. M. Cunnold, F. N. Alyea, S. O'Doherty, P. Salameh, B. R. Miller, J. Huang, R. H. J. Wang, D. E. Hartley, C. Harth, L. P. Steele, G. Sturrock, P. M. Midgley, and A. McCulloch, A history of chemically and radiatively important gases in air deduced from ALE/GAGE/AGAGE. Journal of Geophysical Research, 105, 17,751-17,792, 2000.

WHPO Data Processing Notes

Date	Contact	Data Type	Data Status Summary
05/06/98	Bullister	SUM/SEA/DOC	Submitted for DQE; P14S & P15S data is combined
	P14s/p15s has been updated with a new SUMfile, SEA-HYDfile and additional documentation from John Bullister.		
10/06/98	Anderson	CTD/BTL/SUM	Reformatted by WHPO
	Reformatted .sum file: Changed EXPOCODE from 31DICG96/1 to 31DSCG96_1 and 31DICG96/2 to 31DSCG96_2. Ran over sumchk, no problems. .sea file ok except for first header. · Changed EXPCODE to EXPOCODE. · Changed 31DICG96/1 to 31DSCG96_1 and 31DSCG96_2 to 31DSCG96_2. · Reordered pressures so they are shallowest to deepest. For stas. 21 and 77 .sum file had only cast 2, .sea file had only cast 1. I don't know which is correct so I did not change. Ran over wocecvt, only problem above mentioned cast number discrepancies. CTD - ctd data was ok except for EXPOCODE. Changed from 31DICG96/1 and 31DICG96/2 to 31DSCG96_1 and 31DSCG96_2. Dates in .sum and .wct files for sta/cast 13/1, 16/1, 29/2, 32/1, 39/1, 43/1, 52/1, 74/2, 89/2, 110/2, 121/2, 128/2, 135/2, 167/2, 173/2, and 175/2 do not agree. In all cases the BE time is before midnight and the BO time is after midnight so the day is different. The originator used the BE dates for the ctd's. I did not change the .wct files.		
10/15/98	Mantyla	NUTs/S/O	DQE Begun
10/15/98	Rosenberg	CTD	DQE Begun at WHPO/SIO
11/16/98	Rosenberg	CTD	DQE Complete
11/18/98	Rosenberg	CTD	DQE Report sent to Chief Scientist
11/18/98	Mantyla	NUTs/S/O	DQE Complete
01/11/99	Bullister	CTD/BTL*/CFC	Data are Public
	NUTs, S/O, c14 collected and sent to AMS/WHOI. Checking w/ Quay re c14 data status		
01/11/99	Johnson	CTD/S/O	DQE Report sent to Chief Scientist
	ctdoxy is public, all else in nonpublic		
04/29/99	Bartolocci	DELC13	Data and/or Status info Requested (P. Quay))
07/15/99	Johnson	CTD/HYD	DQE Reports rcvd by PI
	Kristy will be mailing you our responses to both reports (and submitting some revised data) shortly. Please don't make any changes to the CTD data for these cruises until you have our replies in hand.		
08/17/99	Anderson	SUM/HYD	Data files reformatted
	p14ssu.txt: Reformatted to conform with the WHPO standard .sum format. Mostly adding and/or deleting spaces. p14shy.txt: Reordered pressures that were not in descending order. Changed station 21 cast 1 to cast 2 to conform with the sum file: Changed station 77 cast 1 to cast 2 to conform with the .sum file. Ran over wocecvt and sumchk without any errors.		

Date	Contact	Data Type	Data Status Summary
03/20/00	Diggs	SUM/HYD	Website Updated
	SUM and HYD files are now out on the website, and all tables have been updated.		
04/19/00	Bartolacci	DELC14	Website Updated: no samples collected
	However I'd like to clarify this with you, because the DOC file that we have indicates that some 900 or so samples were taken for both C14 and C113, did they not get processed? (There are columns in the data file for both of these parameters that will need to be edited out.) When I first started working for Lynne on the atlas I emailed Paul Quay about this but never got a reply.		
04/20/00	Key	DELC14	No Data Submitted
	P14S15S is problematic. Paul did collect samples which could have been used for C-13 and C-14. I'm pretty sure that many of the C-13 samples have been analyzed. Unfortunately, in his proposal, Paul did not request funding for C-14 analysis. Paul saved an aliquot of the extracted CO2 gas which can be analyzed for C-14 if we can get the funds. We plan on submitting a proposal which, if funded, will cover C-14 anlaysis costs on a few cruises including: P14S15S EqPac (Fall and Spring; NOAA) P1 (Japanese E-W transect) Unnamed German cruise in the upwelling region west of S. Am.		
06/13/00	Bullister	BTL/SUM/DOC	Final Data Rcvd @ WHPO; DQE-related and other updates
	I just re-sent p14sp15s .sea, .sum and .doc files to the WHPO ftp site. The file names are: p14sp15s.doc.senttoWHPO12jun2000 p14sp15s.sea.senttoWHPO12jun2000 p14sp15s.sum.senttoWHPO12jun2000 These files have a number of updates compared to the 'p14s' files now posted at the WHPO web site. Please note that the data in these files (and in the old 'p14s' posted at the WHPO web site) are for both p14s AND p15s- both sections were done on the same expedition. The .sea file now ncludes tcarbn, alkali and pH data; the CFC data are reported on the SI093 calibration scale. We have incorporated most of the changes recommended in A. Mantyla's DQE recommendations. Details of these changes are included at the end of the p14sp15s.doc file sent to WHPO 12 jun 2000. PS: Please note that the formatting instructions given for delc13 in the WHPO 90-1 manual posted at the WHPO web site still ask for F8.1. This should be F8.2. A lot of the value of the delc13 data is lost if they are only reported to 1 decimal precision.		
06/16/00	Bartolacci	BTL/SUM/DOC	Website Updated
	· Re-aligned column headings and date, lat/lon columns. · Changed expocode backslashes to underscores. · Changed expocode from 31DICG96_ to 31DSCG96_ · Added time/name stamp. · ran sumck a second time with no errors. New file named p14sp15s.sum.edt Bottle: · ran wocecvt, warnings on pressure and depth sequencing problems. · Inverted all samples to be in increasing pressure order. · Changed expocode backslashes to underscores. · Changed expocode from 31DICG96_ to 31DSCG96_ · Added time/name stamp. · ran wocecvt a second time with only duplicate depth warnings. New file named p14sp15s.sea.edt DOC: new doc file will replace current online version.		

Date	Contact	Data Type	Data Status Summary	
06/17/00	Bartolacci	BTL/SUM/DOC	Website Updated	files added to website

I have updated the current sumfile and doc file for this cruise as well as the bottle file.

The new bottle file contains:

CTDRAW	CTDPRS	CTDTMP	CTDSAL	CTDOXY	THETA	SALNTY
OXYGEN	SILCAT	NITRAT	NITRIT	PHSPHT	CFC-11	CFC-12
DELC14	DELC13	C14ERR	C13ERR	TCARBN	ALKALI	PCO2
PCO2TMP	PH	PHTEMP				

There is no data in the columns for DELC14, DELC13 C14ERR, C13ERR, PCO2TMP and PHTEMP

Date	Contact	Data Type	Data Status Summary
06/20/00	Bartolacci	BTL/SUM	Website Updated

I have replaced the summary, bottle and added an additional documentation file. All entries and references to this line have been updated. Columns for DELC14/13 and C14ER/C13ER PCO2TMP and PHTMP are filled with missing data values. Bullister has been notified via email that the above changes have been made.

Date	Contact	Data Type	Data Status Summary
06/24/00	Bullister	PCO2	Submitted

Need to be merged into BTL file; See note: I just received a revised pCO2 data file for the P14SP15S cruise, along with a short description of the analytical methods used, all from the PI (Rik Wanninkhof; wanninkhof@aoml.noaa.gov)

I just put 2 files at the WHPO INCOMING ftp site:
p14sp15spco2.dat
p14sp15spco2.txt

Could you please merge the pco2 data into the p14sp15shy.txt file at your site, and include the text of p14sp15spco2.txt in the cruise documentation file?

Date	Contact	Data Type	Data Status Summary	
07/05/00	McNichol	DELC13	Submitted	csv for p15s leg only

I have just uploaded three files p15sbmt2.csv, p15submt.des, and p13submt.des to your ftp site. The csv file contains the following fields in a comma-delimited file: LabID, Trackline, Station, cast, niskin, del13C, QC The LabID is to distinguish between the two laboratories where the majority of the measurements were made--University of Washington and NOSAMS, WHOI.

The files labelled des describe the samples flagged with a "6" in greater detail. Can you accept these as well?

Paul Quay and I would like to append a statement *somewhere* indicating the status of our laboratory data comparisons. Do you have an appropriate place for this?

Date	Contact	Data Type	Data Status Summary
09/29/00	McNichol	DELC13	Data are Public

All the Pacific data (most of which I still need to send you) is public. I should be sending you a pile of data next month.

Also, if the future, if you have a question that you need answered immediately, the best person to get in contact with besides me is Dana Stuart. Her contact info is dstuart@whoi.edu

Date	Contact	Data Type	Data Status Summary
11/21/00	Uribe	DOC	Submitted

2000.11.21 KJU
File contained here is CRUISE SUMMARIES and NOT sumfiles. Files listed below should be considered WHP DOC files. Documention is online.

2000.10.11 KJU
Files were found in incoming directory under whp_reports. This directory was zipped, files were separated and placed under proper cruise. All of them are sumfiles. Received 1997 August 15th.

Date	Contact	Data Type	Data Status Summary
03/15/01	Key	DELC14	Measured as per .DOC
	Funding now available to analyze Got word from Eric this A.M. that he will fund NOSAMS at the rate of 1000/year to analyze previously collected, but unfunded C14 samples. Highest priority will be to fill in Pacific "holes" starting with P14S15S (NOAA), P15N (Wong) and P1 (Japan). Policy decision supported by WOCE SSC. Eric would, if possible, like these data to be included in the atlas. In reality I don't know if this is possible/practical, but I will do everything possible to expedite. Scheduling at NOSAMS will be complicated, but order listed above is the "scientific" priority as of now.		
06/22/01	Uribe	CTD/BTL	Website Updated; CSV File Added
	CTD and Bottle files in exchange format have been put online.		
10/01/01	Muus	CFC/BTL/SUM	Data Merged into BTL file
	CFCs merged into BTL (July), SUM file modified, CSV file updated 2001 CFCs into bottle file, modified SUM file WOCE SECT column to allow conversion to exchange format, made new exchange file and place all on web. Notes on P14S CFC merging Sept 26, 2001. D. Muus 1. New CFC-11 and CFC-12 from: /usr/export/html-public/data/onetime/pacific/p14/p14s/original/20010709_CFC_UPDT_ WISEGARVER_P14SP15S/20010709.173406_WISEGARVER_P14SP15S/20010709. 173406_WISEGARVER_P14SP15S_p14s_ CFC_DQE.dat merged into SEA file taken from web Sept 26, 2001 (20000616SIOWHPODMB) Most "1"s in QUALT1 changed to "9"s and QUALT2 replaced by new QUALT1 prior to merging. CTDOXY has values for Stations 1 through 3 but QUALT1 code is "1". Bottle oxygens taken on Station 1 and from Station 4 on. No bottle oxygens on Stations 2 and 3. QUALT1 code for CTDOXY is "2" from Station 4 on. Left "1"s as quality codes for Station 1 - 3 CTDOXY as caution to users. 2. Conversion from woce bottle format to exchange format failed using the web SUMMARY file (20000616SIOWHPODMB). Modified SUM file by replacing blanks in WOCE SECT columns for Stations 1 - 3 with "x"s. Moved WOCE SECT header so column is left justified. Conversion to exchange file worked after these modifications made. 3. Exchange file checked using Java Ocean Atlas.		
01/22/02	Uribe	CTD	Website Updated CSV File Added
	CTD has been converted to exchange using the new code and put online. Files for station 21 and 77 has a mismatch in the cast number in the sumfile. The sumfile contained data for a cast 1 but the CTD files said cast 2 so the CTD files were modified for the purpose of the conversion.		
06/21/02	Kappa	Doc	PDF & TXT files updted, new sections added:
	New sections include a CTD cast summary and CTD oxygen algorithm parameters tables, HYD DQE report, CTD DQE report, PI response to CTD DQE report, CFC DQE report, Report on CO2fugacity Measurements, and WHPO data processing notes. PDF Cruise Report includes all the above, plus figures and internal links between figures and table of contents and relevant text.		
06/26/02	Tibbetts	Doc	Website Updated; new pdf & text versions online

Date	Contact	Data Type	Data Status Summary
03/05/03	Muus	DELC14/13	Website Updated;Data Merged into OnLine File

Notes on P14S/P15S Mar, 5, 2003 D. Muus

1. Merged DELC13 with 2-decimal-place DELC13 from:
   /usr/export/html-public/data/onetime/pacific/p15/p15s/original/2000.07.05_P15S_MCNICHOL/p15submt2_reformat.csv
   into:
   p14shy.txt (20010927WHPOSIODM)
2. No DELC13 in P14S part of cruise (Stations 1-32).
3. Both QUALT1 and QUALT2 set to QC value given in original data file.
4. C13ERR column was in web bottle with all missing value indicators. No C13ERR data in C13 data file.
5. 6 samples in data file have 2 delc13 values. First was used in merge. Second values follow:

STNNBR	CASTNO	SAMPNO	DELC13	QC
53	1	124	1.03	2
62	2	224	1.41	2
67	2	228	2.12	2*
84	1	105	1.13	2
101	2	202	0.43	2
112	1	132	1.3	2

*First value for 67/2/228 is 1.32, QC=6. Second value looks high.

6. Made new exchange file for Bottle data.
7. Checked new bottle file with Java Ocean Atlas.

Date	Contact	Data Type	Data Status Summary
06/24/03	Swift	PH	Data Update Needed; code truncates 2 decimals

Code is cutting 4 decimals to 2, will have to be fixed. After checking P15S and P14N I am guessing that whatever code were are using to convert 'original WOCE' format to 'WHP Exchange' format is truncating pH to two decimal places. Steve will have to fix the code, and then the staff will have to update every Exchange data file with pH data. '90-1' clearly shows that there is a 4-decimal place specification for pH.

Date	Contact	Data Type	Data Status Summary
07/10/03	Kappa	DOC	PDF and Text docs updated

New CTD DQE report by R. Millard added
Data Processing Notes Expanded

Date	Contact	Data Type	Data Status Summary
07/16/03	Coartney	DOC	Website Updated; New PDF and text docs online
03/02/04	Key	DELC14	Final Data DQE'd, Submitted; No Report

I just finished uploading the c14 data (DELC14, C14ERR, C14FLAG) for p14s15s (the noaa cruise).

As usual, my software hasn't truncated to the correct number of decimal places, it does, on the other hand drop trailing zeroes.

These analyses were funded by a special NSF grant obtained to measure some of the samples which were collected, but without c14 analysis money.

The C14 PI for these data is Paul Quay. Paul also measured the C13 values which are currently in the WHP files. NOSAMS reran the C13, but the NOSAMS c13 values will not replace Paul's values.

I did the QC on the C14 and have already sent copies (merged) back to NSOAMS and to Quay.

Date	Contact	Data Type	Data Status Summary
03/02/04	Key	DELC14	Final Data DQE'd, Submitted; No Report (continued)
	As noted on the submission form (Data quality somewhat lower than norm for WOCE), the data from this cruise (especially the lower station numbers) are noiser than normal for WOCE, but the number of "fliers" is not too bad. Cause is probably extra storage and handling, but that's just a guess. Given the geographic location, these certainly need to be included in any updated versions of the WHP files - that is, they fill a giant data hole.		
03/03/04	Anderson	DELC14	Data Reformatted/OnLine
	Merged the DELC14 and C14ERR from file: 20040302.100353_KEY_P14S15S_p14s15s.c14.WHP submitted by Bob Key into online file: 20030305SIOWHPODM. See email below. The file Key sent had station, cast, and bottle number. The bottle number did not agree with the bottle number in the online bottle file. They did agree with the sample no in the online file if you added the cast number, ie 24 in Key's file was 124 in the online file if it was cast 1 (or 224 if cast 2, 324 if cast 3, etc). Key's file had quite a few stations with sample numbers that were not in the online file, but since there were no DELC14 values for these I ignored them. The online file had -9.0 for all DELC14 values so the QUALT1 and QUALT2 flags were all 9. Key's file had only one Q flag. When I merged the data I used Key's Q flag for both Q1 and Q2. Also, Key's file had a Q flag of 2 for all the -999.0 values, I changed those to 9. Had to add P14S under WOCE SECT for stas. 1-3 in the .sum files in order to get the exchange file made.		
06/29/04	Kozyr	PH	Correct pH values truncated in exchange file
	Andrew Dickson of SIO recently send me a message that for WOCE P14N and P14S sections pH was reported to 2 decimal points in exchange formatted files, but to 3 and 4 decimal points in old WHP formatted files. I did not check other files where pH is reported but I think that it is probably a mistake in that pearl code that converts the data. Could you please check this out. It is very important to have pH reported to 3 or 4 decimal points and many users now copy the data in exchange format.		
07/07/04	Diggs	PH	Exchange values corrected from 2 to 4 decimal points
	I have fixed the code that produces the Exchange files and subsequent NetCDF files. PH is now an F9.4 number. Danie, Jim and I are working on a strategy to re-do all of the files online in the near future.		
11/12/04	Kappa	DOC	Cruise Report Updated
	· Deleted CTD DQE Report by Bob Millard. [Report belonged with P15N Leg 1 CTD data] · Added figures for McTaggart & Johnson's response to the CTD DQE · Added bookmarks to PDF version · Added table of contents to text version · Added introduction to CTD report by K.E. McTaggart and G.C. Johnson · Expanded these Data Processing Notes · Updated OnLine Data History		